HANDBOOK

AND

DIRECTORY

OF THE

CONCRETE INDUSTRY IN INDIA

Compiled by

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BOMBAY.
1929.

PREFACE

There are already a vast number of handbooks and textbooks on the uses of Portland Cement and Concrete published in many languages. In the English language there are those from Great Britain and America which are the usual textbooks used in the British Empire, but these are not always easily obtainable by cement users in India and we therefore hope that this handbook will be found useful.

There are still some people who are inclined to believe that any material manufactured in India cannot be as good as the old imported article to which they were accustomed years ago, and therefore steadfastly endeavour to obtain the imported article refusing to realise that the home product will give them better satisfaction at a lower cost; Modern Portland Cement is a sensitive material and undoubtedly gives its best results when used in a climate and temperature similar to that in which it was manufactured. If for no other reason then, for this alone Indian Cement is obviously the best for use in India.

Some of the following notes and tables have been selected from the publications of the Portland Cement Association of America and the British Portland Cement Association to whom our thanks are due for their permission to use this information.

HANDBOOK FOR THE USE OF CONCRETE IN INDIA.

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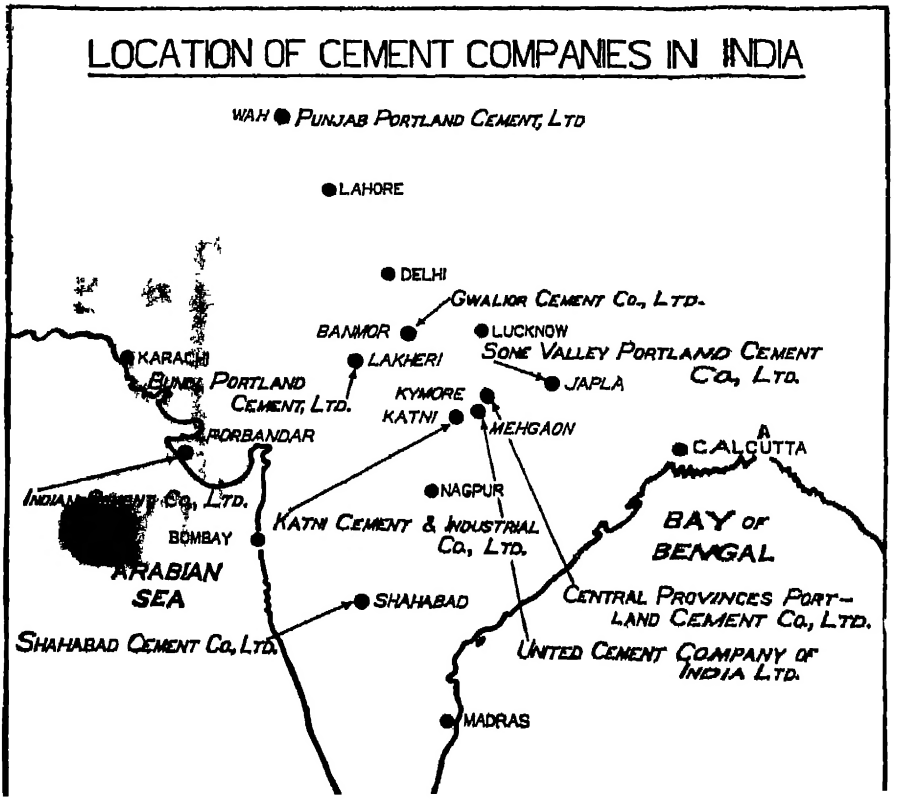
CHAPTER I.

PORTLAND CEMENT.

The development of the Portland Cement Industry in India has advanced rapidly during the last ten years. Until 1913 there was not a single company manufacturing cement in India and all that was used had to be imported.

The first company to be established was the Indian Cement Company, with its works at Porbandar on the coast of Kathiawar State, which commenced manufacture in 1914. Other companies were formed in quick succession until to-day there are ten companies scattered all over India, each fully equipped with the modern plant and turning out high class Portland Cement guaranteed up to, and generally considerably exceeding, the requirements of the British Standard Specification.



The advantages to the population of the country, owing to this establishment of a most important trade are obvious, and cement with its many forms and uses is now available to the whole population with the result that many works of vast importance to the advancement of civilization, such as railways, roads, irrigation, drainage, buildings, etc., have been carried out with speed and economy that were not possible heretofore.

A glance at the map will show how widely the companies are distributed.

The rapid growth of the popularity of cement manufactured in India testifies to the faith that Engineers and Builders have on the product. That that faith has been justified is evident from the success of the vast engineering enterprises undertaken and brought to a successful conclusion with the use of Portland Cement manufactured.

The following figures of Cement consumption illustrate the growth of the industry during recent years.

Portland Cement Consumption in India. (Excluding Burma.)

Year	Imported Cement Tons.	Cement manufactured in India. Tons.	Total consumption. Tons.
1914	150,530	945	151,475
1915	126,465	17,912	144,377
1916	80,543	38,672	119,215
1917	70,313	73,728	144,041
1918	20,016	84,344	104,360
1919	83,097	86,812	169,909
1920	118,507	91,253	209,760
1921	107,009	132,812	239,821
1922	109,924	151,336	261,260
1923	98,481	234,936	333,417
1924	88,416	263,746	352,162
1925	68,200	360,549	428,749
1926	54,800	388,006	442,806
1927	69,000	477,742	546,742
1928	74,700	557,953	632,653

Packing.—Cement in India is packed in Jute bags each containing 112 lbs. gross and as the approximate weight of one bag is 1¾ lbs. approx., the net contents of one bag are 110½ to 110¾ lbs. cement.

British Standard Specification

FOR

Portland Cement.

Revised 1925.

Summary of Tests.

(*a*) Fineness.—Residue on 180 × 180 sieve not to exceed 10 per cent, and residue on 76 × 76 sieve not to exceed 1 per cent.

(*b*) Chemical Composition.—(1) The hydraulic modulus (or ratio of lime to silica and alumina) to be not greater than 2·90 nor less than 2·0.

(2) Loss on Ignition not to exceed .. 3 per cent.
(3) Insoluble Residue „ „ .. 1·5 „ „
(4) Magnesia .. „ „ .. 4 „ „
(5) Total Sulphur calculated as Sulphuric Anhydride not to exceed ..2·75 „ „

(*c*) Tensile Strength (Neat Cement).—Not less than 600 lb.s per square inch (42·18 kg per cm²) at 7 days.

(*d*) Tensile Strength.—(Cement and Sand) 3-1 Sand Cement Portar not less than 325 lbs. per square inch (22·85 kg. per cm²) at 7 days, and 356 lbs. per square inch (25.03 kg. per cm²) at 28 days, with diminishing increase at 28 days on a sliding scale, as per formula, if the seven days' tests are higher than 325 lbs.

(*e*) Setting Time—

Normal Setting Cement.—Initial set of not less than 30 minutes, and final set of not more than 10 hours.

Quick Setting Cement.—Initial set of not less than 5 minutes and final set of not more than 30 minutes.

(The term "quick setting" cement does not necessarily imply that the cement hardens quickly.)

(*f*) Soundness.—Expansion by the Chatelier Test not more than 10 mm. (0·40 in.) after 24 hours' aeration, or 5 mm. (0·20 in.) after 7 days' aeration.

(Reproduced by permission of the British Engineering Standards Association from its Specification No. 12/1925 "Portland Cement," official copies of which can be obtained from Messrs. Thacker

The following is a copy of Standard Contract form for Cement Sales used by the Manufacturers of Cement in India.

CONTRACT FOR

_____ Portland Cement

An Agreement between _____ Portland Cement Ltd. hereinafter called "The Sellers" through their Selling Agents _____ to sell and Messrs. _____ to buy the quantity hereinafter specified of _____ Portland Cement from the Company's Works at _____ on the terms and conditions following, *viz.*

Quantity _____ tons in _____ bags of an average weight of 112 lbs. each.

Weights.—Twenty bags of an average weight of 112 lbs. each to be considered equivalent to a ton of cement. Railway weights to be accepted as correct.

Delivery F. O. R. Works Siding in full wagon loads during _____ for despatch to _____ (all conditions of the railway receipt to be binding on the purchaser)

Price.—Rs. _____ As. (_____) per ton F. O. R

If the quotation is F. O. R. destination and not F. O. R. Works the goods to be nevertheless at the Buyers' risk from the time delivery is made by the Works to the carriers and a clean railway receipt obtained for the goods at the Works siding.

In the case of consignments sold F. O. R. destination the Railway freight to be nevertheless payable by Buyers at destination and the amount of freight shown on the railway receipt to be deducted from the Sellers' invoice.

Payment

Quality—Guaranteed to comply with the British Standard Specification (Revised 1925) in every respect.

In case of any dispute, samples to be drawn in accordance with the B. S. S. and tested by the Government Test House, Alipore, or such other recognised authority as may be mutually agreed. The

Packing.—Woven Jute bags of the usual good quality to be used secured with wire ties.

Refunds on empty bags returned.—For bags returned to the Works and passed as fit for re-issue by the Works Manager, whose decision as to their suitability shall be final, the sum of annas....A ....to be paid for each bag returned freight paid and annas.... B....for each bag returned freight to pay.

General —The cement purchased under this contract being for the Buyers' own consumption or sale at the destination specified above or within their area the Buyers to indemnify the Sellers against any loss or claim resulting from the use or sale of the Cement in any other area.

No complaints to be entertained regarding the goods supplied by the Sellers against this contract unless such complaints are notified to Sellers within seven days from arrival of the goods at destination.

Strike and Accident Clause.—The Sellers shall not be liable for any delay, short delivery or failure to supply which may be caused by reason or on account of or be contingent upon the act of God or the King's enemies, plague, famine, pestilence or epidemic sickness, earthquakes, fires, storms or floods, restraints of Rulers, Princes or peoples war, mutiny, riot or disturbance, strikes or lock-out of workmen, shortage or stoppage of labour breakdown of or accident to machinery or plant from whatever cause, arising, railway restrictions or the failure on the part of railways to supply wagons, failure or shortage in supply of coal or other materials required for the purpose of manufacture directly or indirectly affecting the performance of this contract or any other circumstances of any kind whatsoever beyond the control of the Sellers. Provided that in the event of such delay, short delivery or failure to supply the Buyers shall allow the Sellers as many additional days for delivery as the hereinmentioned circumstances beyond the control of the Sellers may continue.

_____ The Buyers.

_____ The Sellers.

Date_____

A=3 annas } Present current rates 1928
B=2½ annas } subject to variation.

STORAGE OF CEMENT.

Cement being a highly hydroscopic material must be protected from damp. In a country such as India, with an extensive range of climatic conditions, it is difficult to lay down universal rules for the guidance of the cement user

During the dry weather, in some parts of the country, where the relative humidity of the atmosphere, even at night is low, little or no protection may be necessary other than tarpaulin thrown over the stack of cement sacks. But near the coast, or anywhere else when the atmosphere is moist during any part of the day or night, greater precautions are necessary In places where and during periods when heavy rainfalls have to be contended with very particular care must be given to the proper storage of cement to see that it is properly protected from the damp

Whenever there is any possibility of the Cement being exposed to moist atmosphere it should be stored in a well constructed godown, or shed. The cement should not be allowed to lie in contact with the ground but either on two layers of bricks or better still on a timber floor raised about six inches above the ground. The old necessity of aerating cement before use in the works in order to cool, any hot cement is absolutely done away with, by modern methods of manufacture Moreover aeration of modern cement is likely to deteriorate it by allowing it to absorb moisture from the atmosphere

The best method of storing cement is, in bulk either in large silos or bins such as are provided at the Cement Manufacturing Company's works

It is therefore advisable not to store greater quantities of cement than are likely to be used in the immediate future. Thus a supply of fresh cement will always be ensured. On large works where it is necessary to store a few weeks supply, the bags should be stacked in batches of about 400 and they should not be stacked more than 10 bags high If stacked to greater heights than this the lower bags are subjected to too great a pressure and are liable to burst.

For estimating the space occupied by cement in bags in storage it may be assumed that 20 tons cement equalling 400 bags stacked 10 bags high will occupy a floor space 15 ft. by 8 ft. 6 inches and stand about 6 feet high.

CHAPTER II.

CONCRETE MAKING.

Materials—Aggregates—"Fine Aggregate."

The usual specification for Fine Aggregate for use in Concrete work is that it shall consist of sand or stone screenings or other inert materials with similar characteristics, or shall be a combination thereof and be clean, well graded, hard, strong, durable, uncoated grains, free from any deleterious matter such as loam, clay, shells, soft or flaky particles or any organic matter, and for most work it is usual to specify that it shall all pass through a sieve having holes not greater than $\frac{1}{8}$ inch square. In some instance this dimension may be raised to $\frac{1}{4}$ inch square.

Tests.

(1) The first rough test for the suitability of the sand is the feel to the hands It should feel clean. Also if rubbed in the hands and leaves any stain or dirt it is most probably unsuitable

(2) More Accurate Tests should be made in the case of any doubt

The *Sedimentation* test is probably the most common and easiest in practice. This consists of shaking vigorously a selected sample of the sand in a bottle with an equal volume of clear water. After shaking the contents of the bottle it should be allowed to settle for one hour when the quantity of any silt which settles on top of the sand should not exceed 5% of the total volume of the original sand

If the sand does not comply with these requirements it may be washed and the test carried out again until a sufficient degree of cleanliness is attained.

Grading.

Sand that is well graded will have a lower proportion of voids and produce concrete that is more workable than sand with particles all of one size.

All sand should pass on $\frac{1}{4}$ inch sieve and not more than 15% retained on $\frac{1}{8}$ inch sieve.

Fine sands are uneconomical in the use of cement in that they give a low yield of concrete and present a large surface area for coating; also, they stiffen the mix.

All sand should be retained on a sieve having 100 meshes per

Coarse Aggregate.

The usual specification for coarse aggregate is that it shall consist of either broken stone or gravel or other inert material or a combination of these and shall be clean, hard, strong, durable, uncoated, well-graded, free from dust or soft, friable, thin elongated or laminated pieces and containing no organic or other deleterious matter. The use of Dirty Aggregate will only result in weak unsatisfactory concrete. In case of any doubt, the aggregate should be washed Washing is most efficiently carried out by means of a mechanical washer but in some upcountry places, and on small works the cost of a mechanical washer may not be justified.

In that event, hand washing by coolies may be resorted to with some degree of success This consists of placing the aggregate in baskets easily handled and either dipping them in a tank and so washing out any impurities or by washing small batches of aggregate under a strong stream of water from a hose pipe. When using baskets it is important to see that the holes in them do not exceed $\frac{1}{4}$ inch, otherwise the smaller particles which are very important to the concrete will also be washed out.

Grading of Aggregates.

For the purposes of testing sand and aggregates and calculating the fineness modulus a standard set of sieves should be used.

The set of sieves known as the Tyler Standard Set, has the clear opening in each sieve, double the opening in the next smaller sieve.

TABLE OF STANDARD SIEVES.

Sieve No. or Size in inches	Sieve Opening Inches	Wire diameter inches.	Tolerance per cent.			
			Average opening	Wire diameter.		Maximum opening.
				Under.	Over.	
No. 100	0·0059	0 0040	6	15	35	40
No. 50	0 0117	0 0074	6	15	35	40
No. 30	0·0232	0·0130	5	15	30	25
No. 16	0·0469	0·0213	3	15	30	10
No. 8	0·0937	0 0331	3	15	30	10
No. 4	0·187	0 050	3	15	30	10
$\frac{3}{8}$ inch.	0·375	0 092	3	10	10	10
$\frac{3}{4}$,,	0·75	0 135	3	10	10	10
1 ,,	1·00	0 162	3	10	10	10
$1\frac{1}{2}$,,	1·50	0·177	3	10	10	10
2 ,,	2·00	0·192	3	10	10	10
3 ,,	3·00	0 25	3	10	10	10

Water:

Water used in Mixing Concrete must be clean, free from oil, alkali and Acid. In general, water that is fit for drinking

Sea Water or any water containing salt should on no account be used for concrete incorporating reinforcement as the salt will attack and corrode the steel.

Moisture in the Aggregate.

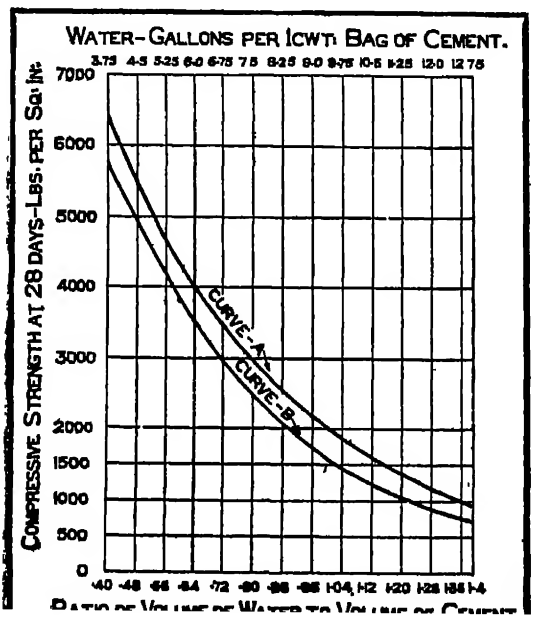
Moisture in fine or coarse aggregate must be taken into account in measuring the quantity of water used in mixing.

Approximate Amounts of free water in Average Aggregate.

Condition of Aggregate.	Imperial gallons per cu. ft. of aggregate.
Very wet sand	0·9 to 1·2
Moderately wet sand	0·5 to 0·6
Moist Sand	0·25 to 0·3
Moist Gravel or Crushed Stone	0·25 to 0·3

Water Cement Ratio.

It is now definitely established that the strength of a concrete mixture depends on the quantity of mixing water in the batch expressed as a ratio to the volume of cement, so long as the concrete is workable and the Aggregates are clean and structurally sound. The strength of the concrete decreases as the water ratio increases.



In the accompanying diagram Curve A may be used for design where the water-cement ratio is very carefully controlled by accurate quantities of water cement and aggregates with a proper correction for the free water contained in the aggregates. Curve B should be used for design when normal conditions of water control and measurement of Aggregates exist and as may be termed usual

Proportioning.

Fine and *Coarse* Aggregates.

The total quantity of water to be used with a sack of cement and its fixed proportion of water should be such as to avoid both over-wet and extremely dry mixes. The proportions of fine and coarse should be such as to avoid foolish extremes in either direction. Even where it gives the lowest cost, too high a ratio of fine to coarse is undesirable as it results in concrete of a lower weight and greater expansion and contraction with changes in moisture content.

Too high a ratio of coarse to fine aggregate is undesirable as it produces a harshness of the mix that makes placing difficult and tends to the production of honeycombing and stone pockets.

A desirable range in the proportions of fine to coarse for average materials is indicated in the following table. Occasionally, aggregates of such grading will be found; the proportions outside the range of this table will be both desirable and economical.

Maximum size of coarse aggregate	Ratio of coarse to fine on basis of Dry compact volumes.	
Inches	Minimum.	Maximum
⅜	0·4	0·8
¾	0 6	1·5
1 and over	1·0	2·0

Slump Test.

No definite measure of consistency and workability of concrete has yet been devised but the slump test affords a useful indication of both these properties. A slump test is no absolute measure of consistency because it does not distinguish between the character of mixes. For example, a harsh coarse mixture cannot be said to have exactly the same consistency as one with a large proportion of sand even though they have the same slump.

When the correct mixtures and proportions have been ascertained, the slump test however will prove a useful indication on the work if any change has occurred in the character of the materials being used, and also any change in the water content of the aggregates.

The standard slump mould is shown in the diagram and also

CONCRETE SLUMP CONE

This can be cut from a sheet 15in wide and 26in long, but lighter than 20 gauge, preferably use 16 gauge galvanized metal.

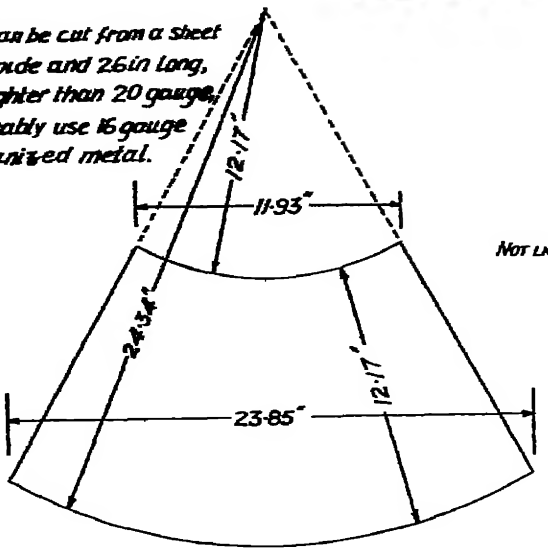
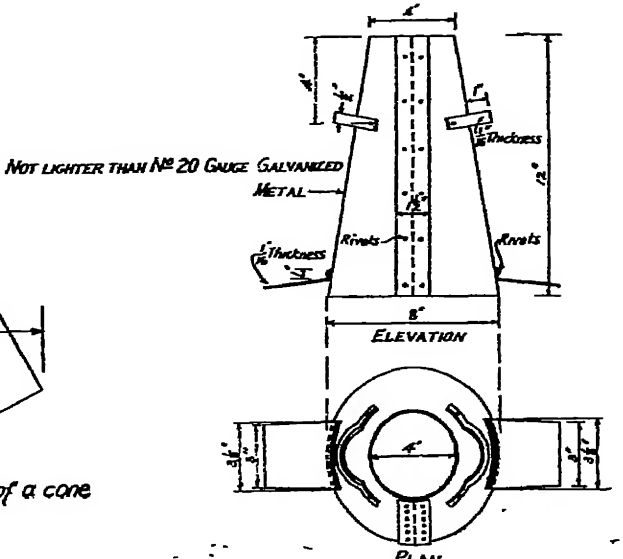


Diagram for cutting metal to make the frustum of a cone used for the slump test.



The method of carrying out a slump test should be as follows :—

The mould shall be placed on a flat non-absorbent surface, such as a smooth plank or slab of concrete, and the operator shall hold the form firmly in place by standing on the foot pieces. The mould shall be filled to about one-fourth of its height with concrete which shall then be punned using exactly 30 strokes of a ½ in. rod pointed at the lower end.

The filling shall be completed in successive layers similar to the first and the top struck off so that the mould is exactly filled The mould shall then be removed by being raised vertically, immediately after being filled. The moulded concrete shall then be allowed to subside until quiescent and the height of the specimen measured.

The consistency shall be recorded in terms of inches of subsidence of the specimen during the test which shall be known as the slump.

Slump=12 minus inches of height after subsidence.

The following slumps are recommended for different types of concrete :—

Class of Concrete	Maximum Slump Inches.
Mass Concrete	2
Reinforced Concrete	
Thin vertical sections	6
Heavy Sections	2
Thin confined Horizontal Sections.	8
Roads and Pavements	
Hand finished	4
Machine ,, ...	1
Mortar for Floor Finishing ..	2

HOW TO MAKE GOOD CONCRETE.

Until the recent discovery that the strength, durability and water-tightness of concrete are dependent upon the proportion of water to cement it was customary to specify mixtures as one part cement to a certain number of parts of sand and pebbles. Modern practice is to state the amount of mixing water for each sack of cement, varying according to the class of work. For example, the recommended mixture for footpaths and that class of work is 4½ gallons of water per sack of cement, when sand and pebbles are in a moist condition. Moisture in the aggregates is [illegible]

were absolutely dry. Had these been dry, the correct amount of water would be 5½ gallons for each one sack batch.

Cement Binds Particles Together.—In a concrete mix, cement and water form a paste which, upon hardening, acts as a binder cementing the particles of sand and pebbles together into a permanent mass. The use of too much mixing water thins or dilutes the paste, weakening its cementing qualities. It is important that cement and water be used in proper proportions to get the best results. This is dependent upon the work.

The accompanying table gives recommended quantities of water for different classes of work and also suggests proportions of cement to sand and pebbles to use in trial batches. The trial batch for footpaths is 1 part cement to 2 parts sand and 3 parts pebbles (1-2-3 mix). It may be necessary to change the amounts of sand and pebbles as will be described to obtain a smooth, plastic workable mix. Under no conditions vary the amount of water from the quantity shown.

The trial proportion (1-2-3) suggested for footpaths may result in a mixture that is too stiff, too wet or which lacks smoothness and workability This is remedied by changing slightly the proportions of sand and pebbles, not the water. If the mix is too wet, add sand and pebbles slowly until the right degree of wetness is obtained. If the mix is too stiff cut down the amounts of sand and pebbles in the next batch. In this way the best proportions for any job may be determined

How to Obtain Workable Mixture.—A workable mixture is one of such wetness and plasticity, that it can be placed in the forms readily, and that with spading and tamping will result in a dense concrete. There should be enough cement-sand mortar to give good smooth surfaces free from rough spots, and to bind pieces of coarse aggregate into the mass so that they will not separate out in handling. In other words the cement-sand mortar should completely fill the spaces between the pebbles and insure a smooth plastic mix. Mixtures lacking sufficient mortar will be hard to work and difficult to finish. Too much sand increases porosity and cuts down the amount of concrete obtainable from a sack of cement.

A workable mix for one type of work may be too stiff for another. Concrete that is to be deposited in thin sections like fence posts must be more plastic than for more massive construction such as walls A good rule to follow is to proportion the sand and pebbles to obtain the greatest volume of concrete correct of plasticity for the work to be done.

Recommended Mixtures for several classes of Construction

Intended primarily for use on small jobs.

KIND OF WORK.	GALLONS OF WATER TO ADD TO EACH ONE SACK BATCH.			TRIAL MIXTURE FOR FIRST BATCH			Maximum Aggregate Size.
	Dry Sand & Pebbles.	Moist Sand & Pebbles.	Wet Sand & Pebbles.	Cement. a/c	Sand.	Pebbles	
				Sacks.	Cu ft.	Cu. ft	Ins
ndation walls which need not be watertight, ass concrete for footings, retaining walls, urden walls, etc.	7½	6	5	1	3½	6	2
ertight basement walls and pits, walls above ounds, storage, cellar walls, etc.	6½	5	4½	1	2½	3½	1½
erstorage tanks, well curbs and platforms, sterns, septic tanks, watertight floors, foot-ths, stepping stone and flagstone walks, ive-ways, porch floors, basement floors, steps, rner posts, gateposts, piers, columns, chimney ps, sills & lintels posts concrete for tree rgery, etc.	5½	4¼	3¾	1	2	3	1
e posts, garden furniture, work of very thin :tions	4½	3¾	3½	1	2	2	¾

Fig. 1

A concrete mixture in which there is *not sufficient* cement-sand mortar to fill the spaces between the stones. Such a mixture will be hard to work and will result in rough, honeycombed surfaces.

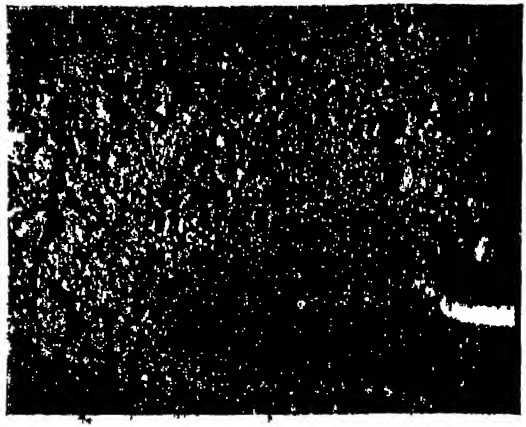
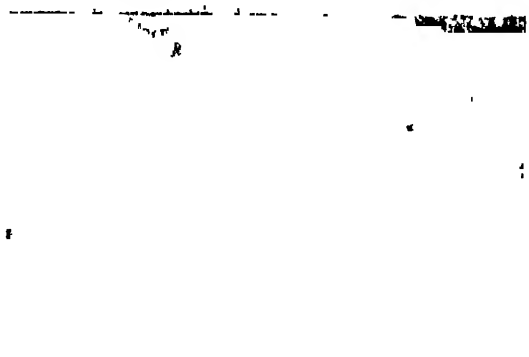


Fig. 2

A concrete mixture which contains *correct amount* of cement-sand mortar. With light trowelling, all spaces between the stones are filled with mortar. Note the appearance on the edges of the pile. This is a good workable mixture and will give maximum yield of concrete with a given amount of cement.

Fig. 3.

A concrete mixture in which there is *an excess* of cement-sand mortar. While such a mixture is plastic and workable and will produce smooth surfaces, the yield of concrete will be low. Such concrete is also



Colouring of Concrete.

Concrete can be made coloured almost to any shade require by adding colouring material. Only meta lic oxides should be use and not in proportions exceeding 15% of the cem nt content b volume. It should always be remembered that the addition c colouring material will weaken the concrete and more cemen will therefore be necessary.

The colouring materials and the cement should be thoroughl mixed together first before being added to the aggregates. Afte mixing, allowance must be made in measuring the cement for th colouring material added.

The following list gives the character and quantities of colour ing material to be used to obtain medium shades :—

Red.	Portland Cement	86	parts	Red Oxide of Iron	14	parts.
Yellow	,, ,,	88	,,	Yellow Ochre	12	,,
or	,, ,,	90	,,	Barium Chromate	10	,,
Blue	,, ,,	86	,,	Azure or Ultramarine	14	,,
Green	,, ,,	90		Chromium Oxide	10	,,
			,,	(Black Oxide of Manganese)	6	,,
Chocolate	,, ,,	88	,,	(Red Oxide of Iron)	4	,,
Black	,, ,,	90	,,	(Black Oxide of Iron or Copper)	2	,,
				(Manganese Oxide or Carbon Black)	10	,,
Pink	,, ,,	97	,,	Crimson Lake (Alumina base)	3	,,

Mixing.

Proper and efficient mixing is essential in all concrete work Machine mixing is always preferable but good concrete can be made by careful hand-mixing.

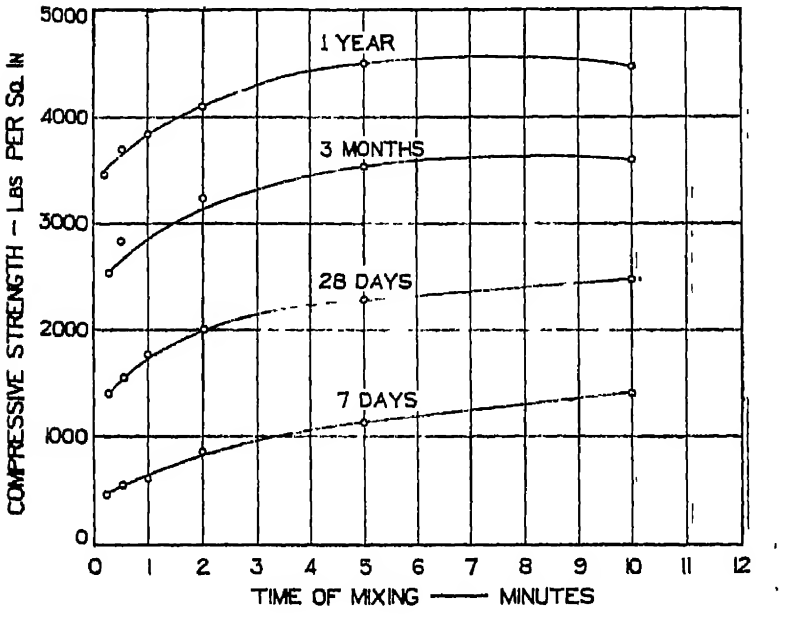
Machine Mixing.

Care should be taken to see that the machine does not run too slow or too fast. With most makes of machine mixers, instructions as to speed are issued. With the majority of machines, speeds varying from 15 to 18 revolutions will be most satisfactory.

Recommended practice is to run the mixer for two minutes after all the materials including water have been placed in the drum.

The time of mixing has a direct effect on the resulting strength of the concrete. The diagram on p ge 17 shows the results of

DIAGRAM SHOWING
THE EFFECT OF TIME OF MIXING ON STRENGTH OF CONCRETE



Hand Mixing.

Hand mixing should be carried out under thorough control and strict measures adopted to see that it is properly carried out.

Mixing should be carried out on a clean paved area or a watertight timber platform at least 7 ft. by 12 ft. with strips fastened along three sides to prevent materials being washed or shovelled off the platform during mixing.

Mixing should be carried out by two men provided with square ended shovels (not powras) with which the material can be lifted and turned.

The measured dry sand for the batch of concrete should first be spread out on the platform making a level heap about 6 inches deep. On this the measured cement should be spread. Then the dry sand and cement should be turned over with the shovels at least three times until they are thoroughly mixed. The measured stone or gravel may now be added and the whole mixture turned over dry again three times. The measured water may then be added slowly through a rose from a watering can while the mixture is continued to be turned over. The mixing should be carried on until the whole has reached an even consistency and the

Do not throw the water from a bucket or bhisti's bag o to the dry mixed materials, or all the labour of dry mixing wi be wasted and the resulting concrete uneven

Curing.

Concrete continues to increase in strength provide moisture is present for a very long time. In India, too muc care cannot be paid to careful curing of concrete and the preven tion of too early drying out. Concrete that has dried out doe not continue to increase in strength but the increase may be starte again by addition of water although the ultimate strength will b lower than that of concrete which has not been allowed to dry out On a paper entitled "Some tests on the effect of age and condition of storage on the Compression Strength of Concrete" presented to the American Concrete Institute by Harrison F. Hornerman the following table is included.

Compression Strength in lbs. per sq. inch at various ages.

	7 days.	28 days.	1 year.	4 years	5 years.
Cured in damp sand .	1,390	1,840	3,765	5,110	5,174
Cured in air of Laboratory.	1,481	2,116	2,350	2,780	2,774
Cured in air for 2 years & 4 months and then in damp sand	1,481	2,116	2,350	3,455	4,058

The results derived show :—

(*a*) Little increase in strength in air stored specimens after an early age.

(*b*) Marked increase in strength of specimens stored under moist conditions upto an age of 3 years and little change between 3 and 5 years.

(*c*) The remarkable increase in strength of specimens cured in air for two years and four months and then cured in damp sand.

In a hot country like India curing of flat surfaces such as roads, pavements, floors, roofs, etc., is best carried out by ponding the surface between small clay or mutti bunds about 3 inches high so that a depth of water of about 2 inches over the concrete can be maintained. Vertical surfaces such as walls, columns, posts, etc., should be covered with sacking constantly kept wet by leaking cans of water placed on top of the structure or by throwing water on to the surface, with hand pumps or sprays.

Curing of small precast articles should be carried out by complete immersion in a tank

CHAPTER III.

CONCRETE ROADS.

A concrete road may be defined as one which consists of a monolithic slab of Portland cement concrete which acts as a wearing surface and also as a load distributing unit.

There are two types of concrete slabs, namely, one course and two course.

A one course concrete slab is such that the proportions of the materials comprising the concrete mixture are uniform throughout the entire depth. It is laid in a single operation except when reinforced, and where mesh or bar mat reinforcement is used it is constructed in two layers in almost a similar manner to the two course. The one course type is the most common.

A two course concrete slab as its name implies is a monolithic slab composed of two layers of different proportions and/or aggregates. The lower course is made of a lean mixture and the upper course of a richer mixture. The top layer is placed before the bottom layer has set so that the two combine into a monolithic mass.

The two course type has economical advantages in places where local aggregates have low wear resisting powers and these aggregates may be used for the lower course and more suitable aggregates imported for use in the upper or wearing surface.

Where local aggregates are suitable, the simpler construction of a one course type of slab with a well designed mixture is to be preferred.

Subgrade.

A study of the subgrade or foundation must be made before he concrete slab can be designed and experience has shown that he following principles are sound practice.

Where the foundation has a good uniform bearing power, a plain unreinforced concrete section should be used. Uniformity s of vital importance, as the subgrade must give an even bearing o the slab. There must be no hard spots or ridges on which the lab may rest, otherwise beam action will result.

Where the foundation is poor, the slab may be increased in lepth or reinforced by bar mat or mesh, whichever is the more conomical. Money spent in careful drainage will often avoid he need for increased depth or reinforcing.

The following foundations are classified as poor from the oint of view of concrete roads.

stresses in the concrete which may cause cracking. When becomes waterlogged it expands, and if frozen when in this w condition it lifts the slab.

Black Cotton Soil, marsh and silt are also considered poor.

The condition of these subgrades may be improved by mea of proper drainage Soils of a clayey nature being difficult drain should be protected as much as possible from the presen of water. Ditches must be so designed that water will not sta in them and should be well away from the road. Drains may al be dug about 30 ft apart in order to carry the water to the si ditches These drains should be about 18" wide at the top a about 6" at the bottom and filled with either clinker or brok stone.

If however it is found to be impracticable or uneconomic to drain certain areas such as spongy sections, a layer of sand sometimes placed on the subgrade or about 3" of clinker or ash which is then rolled to camber.

Sand is a good subgrade material if confined and prevent from flowing out from under the slab, and since water sinks in it quickly, only shallow side ditches are necessary

Dimensions of Concrete Slab - - Tests carried out in Amer have proved that a concrete slab with the edges thickened is t most economical design, and the standard dimensions for subgrade with good uniform bearing powers should be nine inch at the sides and six inches at the centre and without reinforcemer Over embankments, fills, culverts or bridge approaches it shou be increased to 9"-7"-9", and/or reinforced Where it is decid that the foundations necessitate the use of reinforcement the fo lowing information will assist in an economic design The conclusions were arrived at by the Highway Research Boar Washington, D C., after an investigation of the economic val of reinforcement in concrete roads, an investigation that cover conditions on about 3,000 miles of concrete roads both plain a reinforced.

Summary of Conclusions.

1. The amount of cracking and subsequent disintegrati is a function of time , thus, the rate of cracking is a measure of t life of the concrete slab.

2. The data show that steel reinforcement reduced the ra of cracking and thus increased the life of the slab. This appli both to concrete slabs and other surfaces laid upon a concre base.

3. Crack reduction is more economically accomplished

4. A greater reduction was afforded by small steel members closely spaced than by larger members wider spaced

5. Increasing weight of mesh from 25 to 56 lbs. per 100 sq. ft. considerably reduced cracking.

6. Mesh reinforcement, 25 to 56 lbs. per 100 sq. ft., reduced cracks 35 to 70 per cent in slabs of like thickness

7. Mesh reinforcement, 25 to 56 lbs. per 100 sq. ft., and bar mat reinforcement, 64 lbs. per 100 sq. ft, 25 per cent longitudinal, reduced cracks more than one additional inch of concrete, but one additional inch of concrete reduced cracks more than bars (42 to 48 lbs. per 100 sq. ft.) placed transversely only.

8 With good crushed stone aggregate, 56 lbs. per 100 sq. ft. mesh reinforcement, or 170 lbs per 100 sq. ft. bar reinforcement, 50 per cent. each way, caused a reduction in combined transverse and longitudinal cracks equal to that indicated for 2 inches additional centre thickness.

9. Mesh reinforcement of 38 lbs. per 100 sq. ft. has been effective for a thin layer of concrete laid as resurfacing upon an old concrete road.

10. One additional inch of edge thickness reduced corner cracks more than mesh reinforcement 25 to 56 lbs. per 100 sq. ft. or $\frac{3}{8}$ to $\frac{7}{8}$ inch bar reinforcement; but progressive destruction following the appearance of corner cracks was arrested by steel reinforcement.

11. All types of steel reinforcement across cracks tended to hold together fractured slabs.

12. Bar reinforcement across transverse joints, without proper provision for slippage and clearance, resulted in breakage and subsequent expensive repairs.

13. For long slabs, 75 to 100 feet or over, edge bar reinforcement with continuous bond caused corner cracks if the area of steel exceeded $\frac{1}{4}$ sq. inch.

14. A remarkable agreement was found to exist between results of observations on roads in service and results furnished by a wide range of experimental roads and laboratory tests.

When it is necessary to consider the question of either thickening or reinforcing the slab, the relative costs of the two materials must be considered, and although the above conclusions are interesting, yet it will be seen from the following figures that it would be cheaper in India to increase the depth of the concrete rather than to add reinforcement.

Cost in U. S. A. of one sq. yard of reinforcement of $4\frac{1}{2}$ lbs. weight =12 annas.

" " " " " Concrete 1" in depth=22 "

" India " " " Reinforcement of $4\frac{1}{2}$ lbs. weight=16

TYPICAL CROSS SECTIONS

2053.3 Cu yds per mile Area of cross section 10.5 sq ft

¾ Dowel bars across trans joints 4' lg extending 2 units each slab

Parabolic curve

Parabolic curve

9'-0"

½" Def. bars 4'0" lg. 5'-0" c.c.

2379 Cu. yds per mile. Area of cross section 12.146 sq. ft

2'-0"

8'-0"

Shear bars

10'-0"

For heavy duty roads

2248.9 Cu yds per mile Area of cross section 11.6 sq ft.

2-½" Bars in margin of 10'x20' panels

Lower bars bent here

2-½" Bars

3'-0"

4'-0"

3'-0"

10'-0"

5'-0" Shoulder

Longitudinal joint

2411.85 Cu yds per mile Area of cross section 12.333 sq. ft

⅞ Smooth longitudinal shear bar

Circular arc

½" Deformed tie bars 4'-0" long extending raccross concealed long joint spaced 5-0 c. to c.

Crowned subgrade

1'0"

2'-0"

7'0"

Metal center joint

10'0"

Section used in vicinity of cities Bates type used on less traveled rural highways

2200 Cu yds per mile. Area of cross section 11.25 sq. ft.

Edge bar deformed 3 per slab each 14'-2" long

Minimum 7" uniform Usual section 7" center 8" edge

6" 6" 6"

18" Dowels

Construction joint

2'-3" (Max)

Straight line slope ¼ per foot

Mesh reinforcement 40 lbs. per 100 sq. ft. or Bar mat reinforcement 48 lbs. per 100 sq. ft.

9'-0" (Minimum)

3

2053.3 Cu yds. per mile. Area of cross section 10.5 sq. ft

Parabolic curve

Shoulder slope ½" to 1'-0"

1'-0"

2'-0"

2'-0"

2'-0"

2'-0"

9'-0"

4

Preparation of the subgrade.—As already emphasised, the subgrade must be so prepared that it will give a uniform bearing to the concrete slab, and in the case of an old earth road the entire roadway should be ploughed to a depth of at least six inches, then harrowed and compacted with a roller of 8 to 10 tons.

Where an old waterbound macadam road is being resurfaced with concrete it should be scarified to a depth of at least six inches and rolled as described above.

An observance of the roller whilst in operation will indicate the existence of the bad or spongy spots, and the only remedy for these is to drain them by means of tiles or by trenches filled with stones. Where these areas are small, the soft material may be removed and replaced with dry material well tamped by hand in six inch layers.

Where trenches carrying public utility mains, such as water, gas, conduits or sewers exist, these should be filled with the material excavated therefrom, and consolidated by flooding with water if possible. These trenches must have a bearing power equal to the adjacent ground, neither greater nor less.

The slab is sometimes reinforced over these trenches.

A half inch layer of sand should be laid on top of the prepared subgrade if possible; this acts as a lubricant and allows the slab to move freely. The sand must however be clean and free from clay.

Forms.

These must be very carefully laid to line and grade and supported on a uniformly firm foundation. Carelessly laid forms are the cause of many irregularities of the concrete surface and very often spoil the appearance of an otherwise well constructed road. It must be remembered that the screed, tamper and finishing belt all operate on these side forms and by exercising a certain amount of care in this detail a smooth riding surface will be ensured.

Cement should be in accordance with the Concrete Association of India's General Specification for Portland Cement Concrete.

Coarse Aggregates should consist of crushed rock or gravel and be composed of clean, hard, tough, durable material, free from vegetable or other deleterious matter and cubical in shape. They should be well graded from $2\frac{1}{2}$" to $\frac{1}{4}$".

The fine aggregate should consist of clean hard durable uncoated particles free from dust, mica, shells, shale, alkali, organic matter or other deleterious substances.

It must be well graded from $\frac{1}{8}$" down; about 25% to 35 % should be retained on a $\frac{1}{8}$"-screen, 80% to 90% should be retained on $\frac{1}{30}$ screen and not more than 3 % pass a $\frac{1}{100}$ screen.

Mixing water must be clean, free fr[illegible]

Sampling and Testing the Aggregate.—Tests are made befo construction is started, to determine the suitability of materia proposed to be used and these should be carried out from time time. It is not sufficient to rub a handful of sand betwe en th palms and then pass judgment

There are certain easily conducted tests which may be carrie out in the field that will provide quite a reliable standard of com parison, and if the material is still doubtful a representativ sample must be sent to the laboratory

The apparatus and instructions for carrying out those fiel tests are given in Chapter II of this Handbook.

Proportioning and Mixing of Concrete.

This should be carried out in accordance with the Concret Association of India's General Specification for Portland Cemer Concrete as applied to roads A concrete giving a compressiv stress at 28 days of 3,000 lbs per square inch is required.

Placing of Concrete.

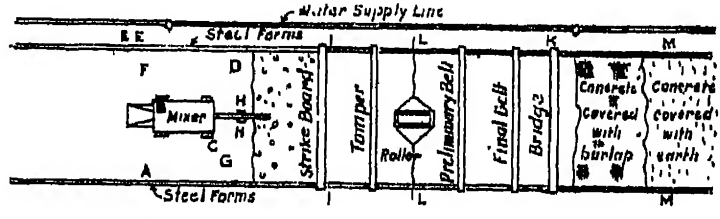
The subgrade must be at the proper elevation to give th full thickness of concrete slab at all points

It is better to have the subgrade thoroughly wet a day ahea rather than just before placing the concrete.

When the batch is placed on the subgrade, shovellers mus be careful not to get earth mixed with the concrete.

Construction Method.

There are several methods of laying the concrete slab an frequently these are governed by whether the entire road can b closed to traffic or not.



A. Overseer
B Mixer Operator
C Batch Operator
D Subgrade
E Form Setter
F Water Boy
G Joint Man
H Concrete Distributors
I Strike-off Board Men
K Finisher
L Finisher's Helpers
M Laborers to cover finished pavement

CONCRETE PAVING PLANT LAYOUT

Continuous Construction.

The concrete slab is laid in one continuous operation and at the end of the day's work it is finished off at a transverse bulkhead.

Cracks are bound to appear in this type of construction even though the proper precautions are taken, due primarily to contraction of the concrete.

These cracks are a disfigurement and although they do not add much to the cost of maintenance it is best to eliminate them if possible.

Alternate Bay.

The whole width of the road should be available, although it may also be done in half widths.

The concrete is deposited in alternate bays, and the intermediate bays are filled in after the former have been cured, thus allowing the initial contraction to take place.

Very often, however, these bays crack down the centre of the slab, and unless very carefully supervised, the slab at the construction joints may not be level, thus causing abrasion and an unequal riding surface, and as the public judge the road by its smoothness this is to be avoided if possible.

The transverse joints are either at right angles or at angle of 60° to the longitudinal axis of the road, and the length of the bays should not be more than 20 feet. Where diagonal joints are used the screeding and tamping is done longitudinally, that is the screed and tamper rest on the transverse forms.

The joints in the alternate bay method are usually plain butt, and the face of the alternate bays is sometimes coated with a bituminous paint before laying the intermediate ones.

Strip Method.

This is the most successful method of avoiding cracks and these should not develop in a concrete road laid in longitudinal strips.

The strips should not be more than 12 feet wide and transverse expansion joints must be placed every 30 ft., or every 90 ft., with 2 dummy joints between.

Expansion Joints.

By using expansion joints the concrete is allowed to expand and contract at regular intervals, thus avoiding cracks, and fewer joints are required than in the alternate bay method. The expansion joints should be ½" to ⅝" wide and filled preferably with a premoulded filler composed of asphalt cement, with or without a mixture of wood fibre, placed between two sheets of impregnated cardboard or felt, which acts as a stiffener and makes it easier to handle and instal.

The edges of the joint must be rounded to $\frac{3}{8}$" to $\frac{1}{4}$" radius and great care should be taken that the concrete on either side is true to grade This can easily be done by the frequent use of the straight edge.

These joints must be filled periodically with some bituminous material otherwise wear or abrasion will take place.

The joints are spaced about 30 ft apart and the concrete laid as in continuous construction.

Where poured joint fillers are used a well greased sheet of steel is set in the joint until the concrete is hard, then removed and the joint filled with heavy tar or hot asphalt. Care must be taken that the sheet of steel is secured against deflection

The joint must remain a true vertical plane to prevent the tendency of one section rising above the other.

During the construction of the expansion joints the premoulded joint filler may be held in position by several methods such as a wood or a metal bulkhead, which is slotted if dowel bars are used

Metal pins are sometimes used to support the premoulded filler.

Where steel dowel bars are used across transverse expansion joints, one half of the bar should be completely encased in a heavy paper cardboard tube in such a manner as to prevent adhesion between the concrete and the steel, and in addition some form of cap must be provided at the end of the bar to provide for sliding.

DETAILS OF DOWEL BARS AT TRANSVERSE EXPANSION JOINTS

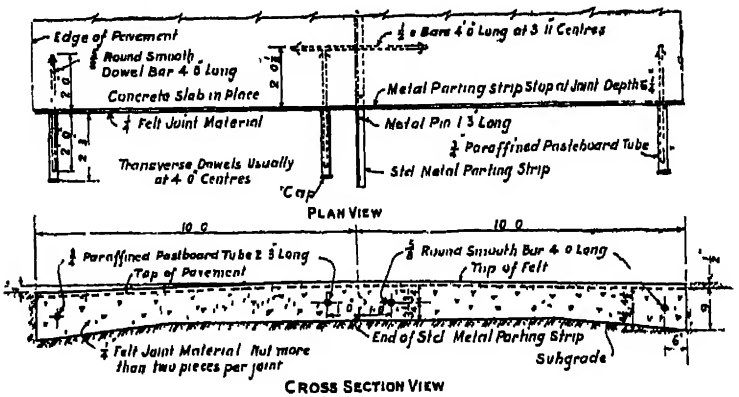


Fig 3.

Dummy Joints.

Dummy joints are used to localise cracks that may occur due to contraction. They are formed by pressing into the green concrete some form of cutting edge which forms a slot

joint filler is then placed in the groove, the last finishing of the surface is then carried on over this strip of joint filler and the edges rounded with an edging tool.

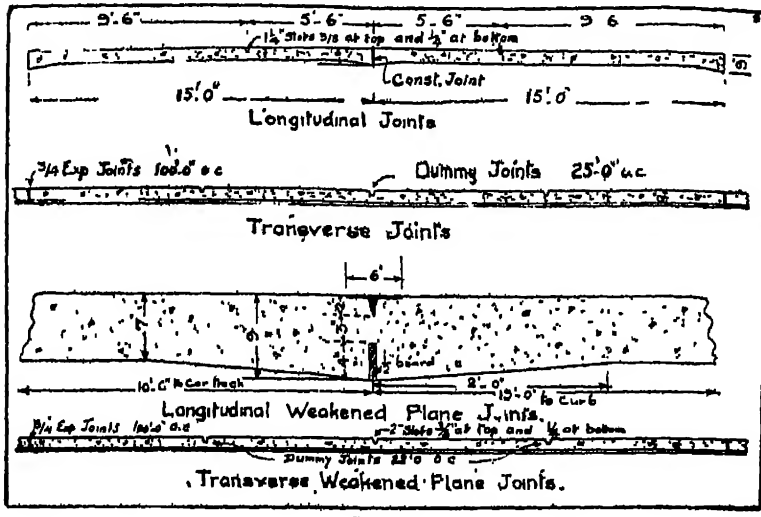
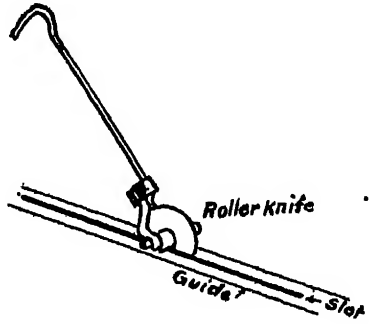


Fig. 4.

Methods of cutting groove or slot.

A roller knife with a double guide. This can be operated by one man.



Roller Knife

Fig. 5.

After the slot is cut and before the double guide is removed the joint filler is pressed into the slot. This premoulded filler strip is usually ¼" thick and 2" wide.

A tee iron fastened to the bottom of a wooden beam is forced into the concrete by two men, forming the groove.

Longitudinal centre joints may also be formed by this method

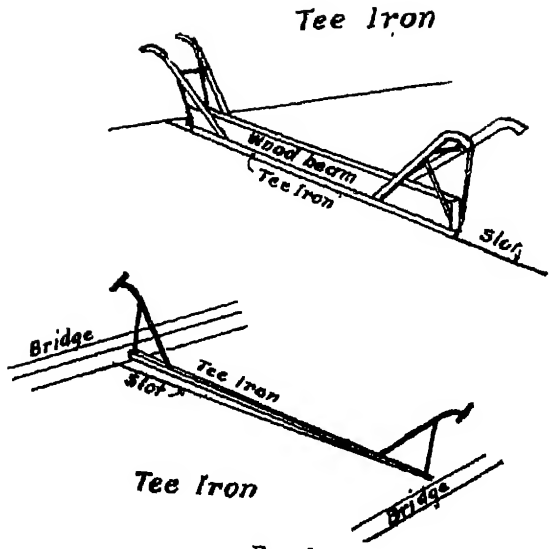
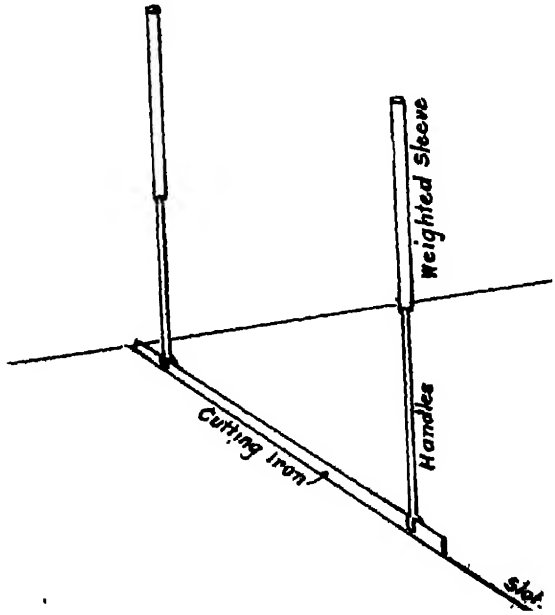


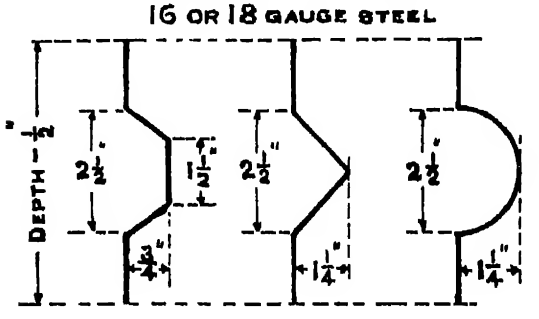
Fig. 6.

A piece of steel plate with vertical handles may be used ; the workmen put their weight upon the cutting iron by means of the long vertical handles and weighted sleeves sliding on these handles are used as hammers to sink the iron.



Longitudinal centre joints may be tongued and grooved so that the pressure is distributed over the two strips, and this is done by inserting a deformed plate.

The following indicates the more common types used.



LONGITUDINAL CENTRE JOINT PLATES.

Fig. 8

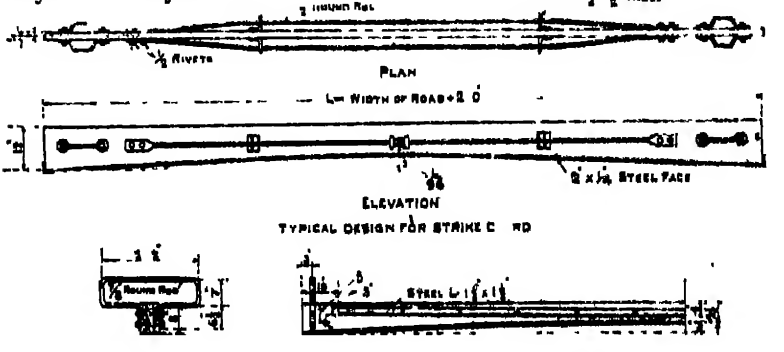
Where the pavement is laid in half widths these plates can be removed with the centre form as there is no advantage in having the plate in the joint.

Some engineers omit the dovetail altogether.

Dowels are sometimes used across the longitudinal joint and consist usually of ⅝" rods 5 ft. long spaced at 5 ft. centres

The use of dowel bars in transverse and longitudinal joints must be left to the opinion of the Engineer. Their use is becoming common practice, but a sufficient length of time has not yet elapsed to enable judgment to be passed on their value.

Striking or Screeding the Concrete.—After the concrete has been dumped on the subgrade it should be spread with shovels immediately as nearly as possible to the finished camber of the road, and then struck off to the correct shape by means of a strike board, template or screed working on the side forms. This should be moved forward with a combined forward and transverse motion, and when within about 3 feet of the transverse joint the screed is lifted to the joint and the concrete struck by moving the screed away from the joint.



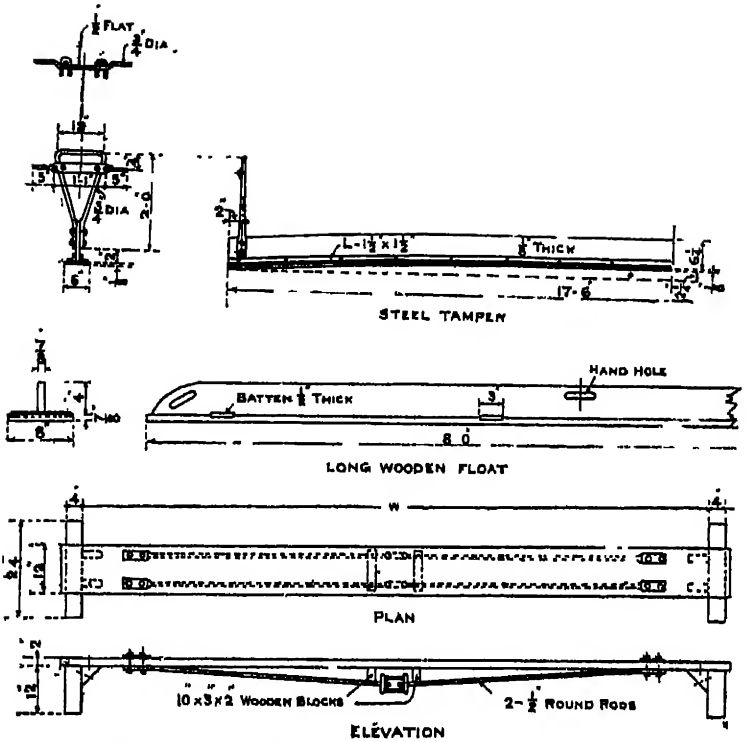
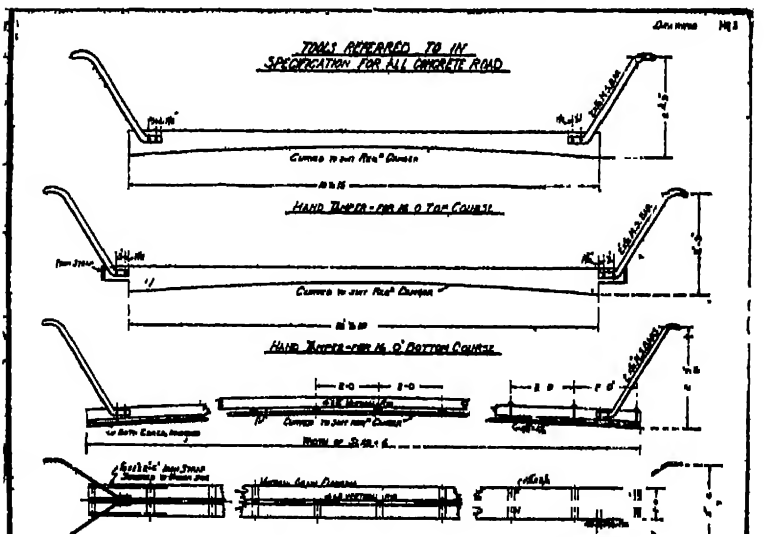


Fig. 10. TYPICAL DESIGN FOR FINISHER'S SPIDGE



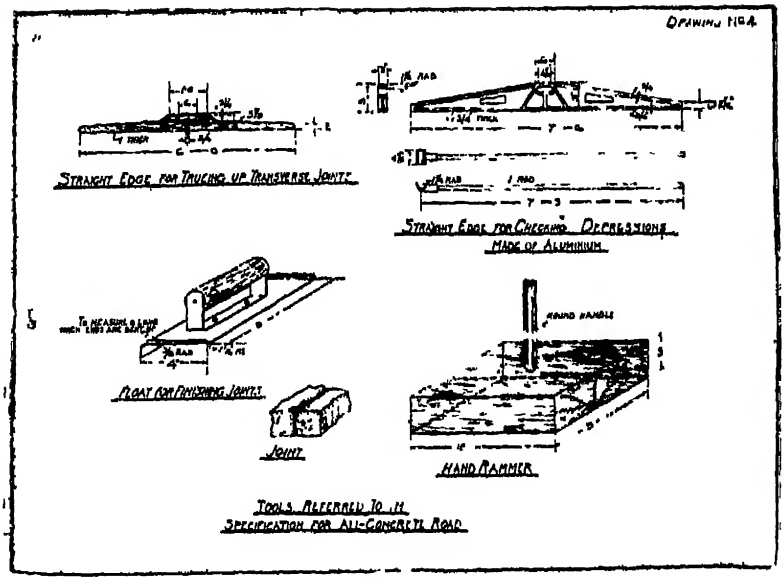


Fig. 12.

Tamping.

The concrete should be well consolidated and a tamper similar in shape to the screed or strike board is used. Sometimes screed and tamper are combined in one implement.

A gauge board sliding on the forms and provided with metal fingers ½" to 2" apart adjusted to the crown may be used to guide the finishers. The fingers scratch or fail to mark the concrete wherever it is high or low.

Finishing the surface.

It is very essential that all finishing operations be reduced to a minimum and tamping should cease at that point when the coarse aggregate is just submerged.

The ideal concrete road surface has a mosaic appearance, that is to say the coarse aggregate is exposed.

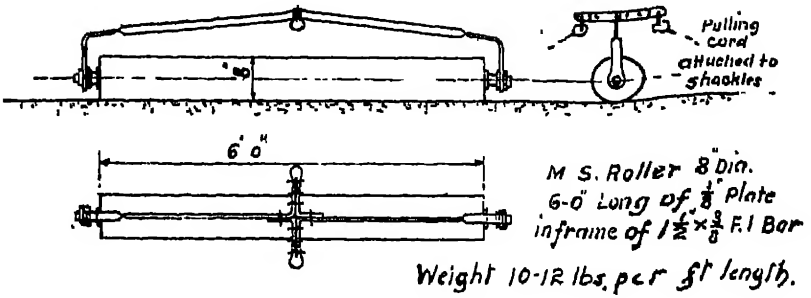
There are several methods of finishing the surface.

After the concrete surface has been screeded and tamped it may be floated by means of a longitudinal float or rolled transversely with a roller.

The final finishing is done by means of a belt.

Where the concrete slab is laid in strips of about 10 ft. width two screedings and one belting should be the aim as far as finishing

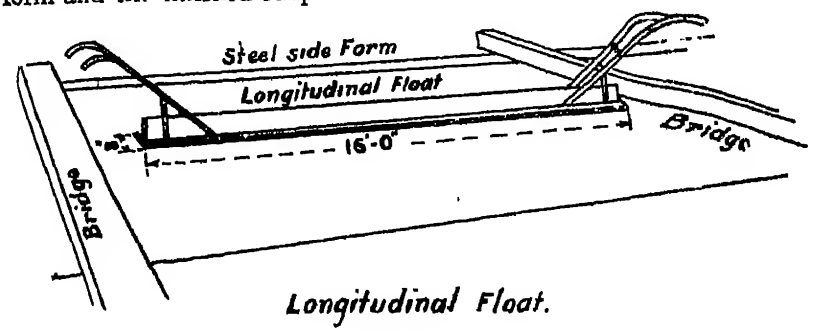
and also slowly working forward. Two to four rollings are given at 5 to 10 minutes intervals.



ROLLER FOR SURFACE FINISH

Fig 13

The Longitudinal float is operated from bridges resting on the outside forms or in the case of the strip method on the outside form and the finished strip



Longitudinal Float.

Fig 14.

The float should be laid on the concrete surface with its long dimension paralleled to the centre line of the road and drawn backwards and forwards with slow strokes about 2 ft. long and slowly advancing from one side of the road to the other. This will remove any transverse waves and produce a uniform even surface on the concrete.

Finishing Belt.

This consists of a canvas or rubber composition belt about 8 inches wide with cross-bar handles at each end and 2 ft. longer than the width of the pavement. It is operated by two men. Immediately the concrete has been tamped or rolled the belt is see-sawed backwards and forwards across the slab with fairly long strokes about 12", slowly advancing; a second belting is given

Sometimes a final belting is given just before the initial set and this is with short strokes and rapid advance. This should leave a smooth gritty surface. The belt must be cleaned at the end of the days work, and thoroughly soaked before being used and kept wet. Frequently the belt is oiled to keep it soft and prevent the concrete from adhering to it.

The finished surface of the concrete must be tested by means of a light straight edge about 10 ft , in length laid paralleled to the centre line of the pavement This is done just prior to the final finishing operation.

Brooming.

Where it is desired to have a roughened surface, this may be accomplished by brooming the broom being pulled gently over the surface perpendicular to the longitudinal axis of the road The broom should be of the leaf rake type with flexible prongs

The brooming is carried out immediately after the belt finish.

Curing and Protection.

After the concrete surface has been finished by means of the belt it must be prevented from drying out too quickly ; it should be covered immediately with canvas, and this must be sprayed with water but in such a manner that the surface of the concrete will not be damaged, and the canvas is kept moist until the following morning It should then be removed and the concrete covered with moist earth 6" thick and this must be kept continuously moist by spraying for at least 14 days after laying

The curing may also be carried out by ponding Earth walls or dikes are built along both edges of the slab with cross walls at sufficiently frequent intervals, and the slab flooded with enough water to completely cover the concrete and kept flooded for 14 days.

A sodium silicate solution of calcium chloride is sometimes used to cure the concrete surface

Hardening the Surface of the Concrete.

Hardening is effected by applications of a solution of sodium silicate sprayed on the surface by means of a watering can, and continuously brushed over the surface with a soft broom for several minutes to obtain an even penetration.

Three applications are given allowing 24 hours to elapse between each.

The solution should be in the proportions of one part of an 8 per cent., solution of commercial sodium silicate to four parts of water and one gallon of the solution will cover 200 sq. yards.

This solution may be applied either after the curing is com-

The surface of the concrete must be dry and free from dus before the application of the solution.

This treatment would be unnecessary where sodium silicat had already been used for curing.

Two-Course Roads.

In two course construction the concrete is deposited rapidl on the subgrade to the required depth and for the whole widtl between longitudinal joints. The bottom course should be struc off at the correct elevation with a template or screed riding o the side forms, and the top course must be placed within r minutes after laying the bottom course.

City Streets.

All the foregoing notes will apply generally to city streets The concrete slab may be of the same thickness throughout, althougl some engineers increase the centre thickness and others the edg thickness.

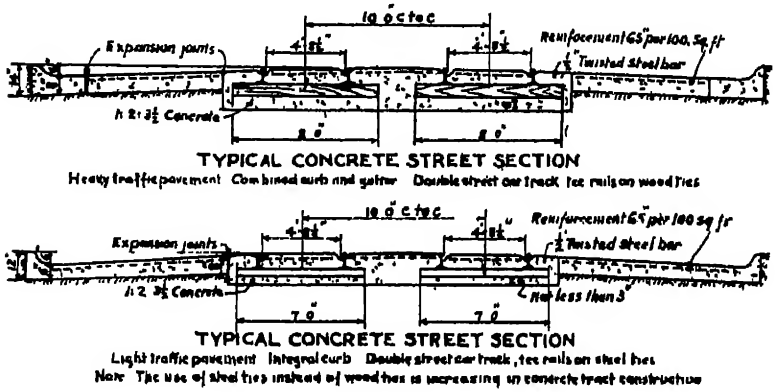


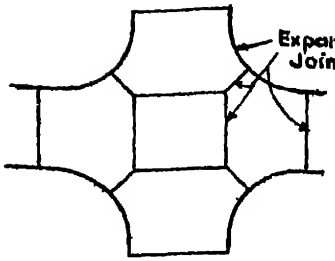
Fig. 15.

Longitudinal expansion joints are very seldom placed in the slab itself, except where it is extremely wide. The joints along the sides are made sufficiently wide to make any in the slab unnecessary.

It is safer to provide an excess of longitudinal expansion joints in city streets.

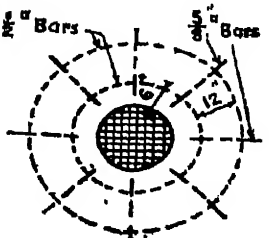
Transverse expansion joints must extend through curb and gutter where these are integral with the slab.

Street intersections should be well provided with expansion joints and all manhole covers should be surrounded by expansion

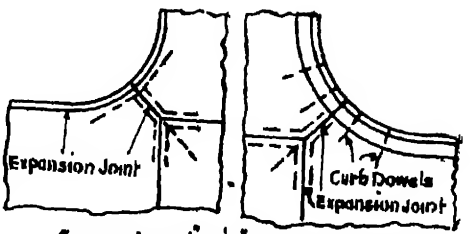


¾" dowel bars at 3ft centres are usually inserted.

Expansion Joints at Intersections



Reinforcing at Manhole



Corner bars ½" 5'-0" Long set 4" from edge and 2" below surface

Plain Curb

Doweled Curb & Gutter

Fig. 16.

CHAPTER IV

CEMENT MACADAM ROADS.

In a cement macadam road the road metal or stone is bound together by cement mortar, and when properly constructed on a *good uniform foundation* it should have a life of at least eight to ten years There are roads of a similar construction in Scotland which have been in existence for over 50 years with practically no repairs. There are others in America which have had a life of at least 10 years, and to-day these American roads are being resurfaced with 4″ to 5″ of concrete and on completion they will come under the category of first class roads ; that is, they will then be capable of carrying the heaviest vehicular traffic. This has been made possible by the excellent condition of the old *Cement Macadam road* enabling it to be used as a foundation for the new concrete surface.

The construction of the cement macadam road is very simple and the labour and plant of road building organisations accustomed to Waterbound Macadam construction require very little change to adopt them to this form of construction.

The construction of the cement macadam road is carried out in the following manner.

A good average uniform foundation is necessary and if the old foundation has potholes or ruts it should be scarified and well rolled or the depressions filled with broken stone and thoroughly rolled.

The subgrade must be hard and firm otherwise the mortar will percolate into it.

If the old road has a fairly impervious surface such as tarsprayed or bituminous, brush it well and lay the new surface without any further treatment.

A layer of ½″ of clean sand is placed between the existing road and the new cement macadam surface.

The roller should be about 8 to 10 tons in weight and preferably of the tandem type, otherwise the front roller should overlap the rear wheels.

After the subgrade has been prepared, forms are laid on both sides of the road if it is to be constructed to the full width, or if in half widths one form is laid along the centre of the road and

These forms are laid to the correct line and grade and if of wood they should be not less than 4 inches wide and have a depth equal to that of the finished work and should be securely held in position.

Permanent curbs of brick or concrete may be built to act as side forms

After setting the forms, a layer of broken stone of sufficient depth to produce half the required thickness of the completed slab is spread evenly on the prepared subgrade

The finished thickness should be approximately 4".

This first layer of broken stone is then rolled to pin the stones together, the roller passing over not more than twice.

Give a light watering to remove dust and fine particles. Preferably all the stone should be watered before spreading, otherwise the dry stone will absorb moisture from the mortar.

Whilst the above operations are being carried out the cement and sand are mixed dry in the proportions of one part of cement to two parts of sand. This dry mixture is then spread over the layer of stone, laid as described above, to a depth of at least one inch and on this layer of dry mortar spread another layer of broken stone equal in depth to that already laid. The materials now in position consist of approximately 2½ inches of stone, resting on the subgrade, at least one inch of dry mortar on top of this and an upper layer of approximately 2½ inches of stone.

Water is now sprinkled over these materials, and starting from the side of the road and working longitudinally the roller should thoroughly consolidate the materials until the mortar is brought to the surface, which will occur in about ten minutes

An excess of water is to be avoided and the quantity kept down to a minimum.

As soon as the mortar shows up, the surface is given a soft brushing.

Rolling is continued until the slurry has worked up and all raw patches have been filled.

These raw patches should not occur and are mainly due to too much water or insufficient mortar between the layers of stones. Any voids or raw places are filled with grout after the section has been completely rolled.

Where it is impossible for the roller to consolidate any part

Immediately a section is completed the surface should be covered with moist canvas and this is kept moist until the following morning. The Cement Macadam surface must then be prevented from drying out too rapidly by any of the customary methods for curing concrete such as moist earth or ponding, and this curing is continued for at least 14 days.

The same care must be taken in curing a Cement Macadam road as would be taken in an ordinary concrete road.

To remove any inequalities such as roller wheel marks, a 9"× 6" screed long enough to work over the side forms may be used with a tamping movement after the rolling is completed, or a hand roller used transversely may be employed. The screed must be shaped to the camber of the road.

It is important that the roller should not pass over any portion of the Cement Macadam which has already set, and rolling operations must not be continued over any section for a period longer than 1½ hours in cold and one hour in hot weather. It is essential that this period be carefully observed and that the time be reckoned from the moment the water is sprinkled over the prepared material.

The area that can be rolled in one hour is approximately 30 to 40 sq yards or a length of 22 to 30 ft. of a 12 foot width of roadway. Too large a section should not be attempted at first until experience has indicated what area can be completed by the organisation in the time limit of 1 to 1½ hours allowed for rolling.

The end of each section should be clearly defined by means of secured timbers, and care must be taken that the roller does not pass over the previous section.

To avoid damage, the top layer of stone must not be placed within a foot of any finished work, and this should be dealt with by a man or men specially detained who will complete the part by adding the required stone and consolidate it by means of a hand tamper. The level across the joint must be carefully checked by the use of a straight edge

This last injunction is important as the construction joints being numerous in this type of road unevenness will be noticeable, and will also tend to abrasion at these joints.

When the construction is carried out in half widths great care must be taken that the side wheel of the roller does not work on the edge of the finished slab along the longitudinal joint.

After the new section has been consolidated, the roller may straddle the longitudinal joint and level it off.

If the edge of the finished slab should be broken down or crushed by the roller the damaged portion must be cut out and

To finish off the day's work a timber baulk is laid down transversely and spiked. The following morning it can be lifted and there should be a clean, vertical consolidated face to work to. Work will then begin in the same manner, the stone being spread up to the joint and the dry mortar deposited well into it It will be obvious that the roller must not run over the previous days work and can only roll up to the joint and not over it. The joint must be carefully levelled by ramming by hand.

If desired the surface may be treated with silicate of soda.

An experimental length of Cement Macadam road was laid in Lucknow in accordance with the method just described, and after carrying heavy traffic for about a year the surface to-day shows no indication of wear or cracking.

The cost of this road surface which is approximately 4" thick was Rs 2-2 per square yard exclusive of overhead charges.

Specifications for a Cement Macadam road may be had gratis by applying to the Secretary, the Concrete Association of India, Bombay.

CHAPTER V

CONCRETE PRODUCTS.

The term "Concrete Products" has become universally recognised to represent innumerable small precast concrete units used chiefly in building construction. Among such articles, which usually find a ready sale, are the following —

Concrete Products for

(*a*) *Buildings, including Bungalows, Factories, Offices, etc.*— Building Blocks, solid and hollow of varying shapes and designs, Fire Places and Fire Surrounds, Lintels and Window Sills, Door and Window Frames, Roofing and Floor Tiles of various designs, Slabs and Bricks, Staircases, Columns and Verandah Posts, Partitions,—Arches, Gate Posts and Gates, Window Shades, Chimney Blocks, Cisterns Floor and Roofing Beams, Gutters, Finials.

(*b*) *Architectural Features.*—Cornices, Balustrades, Column Capitols, Ornamental Keystones, Coats of Arms, Low Relief Work, Pierced Concrete Panels

(*c*) *The Farm*—Cattle Troughs, Well Lining Blocks, Grain Bins, Drain Pipes, Gates and Fences, Small Tanks and Sumps, Sectional Buildings, Launders.

(*d*) *Roadways*—Milestones, Direction Signs and Posts, Kerbstones, Channels, Manholes and Covers Pavement Flags, Sectional Culverts, Bridge Slabs Concrete Setts, Half-round Gutters.

(*e*) *The Garden.*—Seats, Fences, Flower Boxes, Ornamental Vases, Sundials, Bird Baths, Edging Tiles, Crazy Pavements, Statues, Pergolas.

(*f*) *The Railway*—Name and Notice Boards for Stations, Paltform Seats, Signal, Gradient, Mile and Disc Posts, Wash Basins and Baths, Sleepers of various Designs, Platform Walling, Sectional Latrines and Latrine Seats, Platform Pavings

(*g*) *Electrical Undertakings*—Lamp Standards (plain and ornamental) Power Transmission Poles Cable Boxes.

(*h*) *Water Works and Sewage*—Pipes 4" bore and upwards, Septic Tanks.

(*i*) *General Utility*—Drinking Fountains and Troughs, Tennis Court Surround Posts, Monuments, Dust Bins, Tree Guards, Vaults and Tomb Stones, Black Boards, Anchors Shelves Ornamental

In order to avoid repetition, some items in the above list appear under one heading only, though the particular product mentioned. may also be common to the others ; it is therefore necessary to bear this in mind when using the list for reference purposes.

These concrete units are not only stronger and more capable of hard usage, but they can be economically manufactured and compete very favourably, sometimes with a large margin of profit with similar articles at present manufactured in other materials, whether these are stone-ware, burnt clay, dressed stone, cast iron or any other material.

Concrete products are made either near or at the site of works where they will be required or manufactured commercially at a special factory erected and equipped for the purpose.

With a view to furnishing some particulars on the costs of various units to prospective manufacturers of concrete products, experiments were carried out by a representative of Concrete Association of India at one of the cement Manufacturing Companies' Works where there is installed a small experimental Concrete Products Factory. Careful measurements of all materials used were taken and the time required to make various articles was recorded. Thus the actual cost of Labour and Materials was arrived at.

The results of these experiments are given in the accompanying tables From these it can easily be seen that, even in the experimental stages concrete roofing tiles, blocks, pipes, balustrading, etc , can be made at economical figures though the tests were carried out with untrained workmen and all the concrete was handmixed which requires more labour than if a concrete mixer had been used.

In order to arrive at actual estimates of cost of manufacturing these in a business concern, there are of course several additions to be made, such as cost of efficient supervision, plant, rent of site, and buildings, etc , before an economic selling price can be arrived at ; but even with normal additions for these items it will be seen that there are many places, where local sand is good and cheap, at which there can still be a considerable margin of profit in manufacturing concrete products.

The cost of labour and materials mentioned in the accompanying tables can be considerably reduced when manufacture is conducted on a large scale.

TABLE No. 1.

"CONCRETE PIPES" (Spigot & Socket Type)

Details of Quantities, Output and Costs.

For the purpose of these experiments the following prices were assumed.

Cement at Rs. 55 per ton. Sand at Rs 2-5 per ton (Rs. 9 per 100 c.ft.)

Labour: Coolie at 7 as a day, boy 4 as a day.

The cost of the pipes is exclusive of the initial expenditure on pipes moulds and other subsidiary plant, also exclusive of the of supervision and other overhead charges.

de of e.	Length without socket.	Length of the socket	Weight of each lb.	% of vol of water to total vol. of materials	Thickness of Concrete	Per 100 pipes of mix. 1 cement and 2 sand							Output per day on one mould.
						Cement required lbs.	Sand required lbs.	Cost of cement Rs.	Cost of Sand Rs.	Cost of Labour. Rs.	Waste 1% Rs	Total Cost Rs	
	2′	2″	27	13·5%	¾″	880	2,094	21·4	2·17	3·82	0 24	27·63	18 pipes (by one coolie and 2 boys)
	2′	,,	42½	12·5%	⅞″	1,300	3,060	31·83	3·16	4·9	0·35	40 24	14 pipes -do -
	2′-6″	,,	81	11·7%	1″	2,520	6,000	61 92	6·2	6 87	0·5	75 49	10 ,, -do -
″	3′-4″	,,	294	10%	1″	5,050	11,200 sand 18,900 grit	146·5	11·5 sand 7·17 grit	17·5	2·0	172 67	6 ,, (by 4 coolies & one boy).
						Per 100 pipes of mix. 1 cement and 3 sand.							
	2′	2″	25½	14·0%	¾″	616	2,200	15·15	2·27	3·82	·175	21 265	18 pipes (by one coolie and 2 boys)
	2′	,,	40	13·0%	⅞″	925	3,300	22 7	3·4	4 9	·261	31·261	14 pipes -do -
	2′-6″	2″	78	12·1%	1″	1850	6,600	45·4	6·8	6·87	·5	59·57	10 ,, -do.-
						Per 100 pipes of mix. 1 cement and 4 sand							
	2′	2″	25	14·5%	¾″	600	2,300	14·75	2·37	3·82	·175	21·115	18 pipes (by one coolie and 2 boys)
	2′	,,	40	14·5%	⅞″	890	3,400	21·8	3·52	4·9	·175	30·395	14 ,, -do.-
	2′-6″	,,	71	12·8%	1″	1,500	6,700	37·0	6·57	6·87	0·4	50·84	10 ,, -do.-

TABLE No. 2.

"CONCRETE BRICKS AND TILES" Details of Quantities, Output and Costs.

For the purpose of these experiments the following prices were assumed.

Cement at Rs. 55 per ton — Good Sand at Rs 2-5 per ton (Rs 9 per 100 c ft)

Local Sand at Re. 1-9 per ton — Ballast at Re 0-13-6 per ton (Rs. 4 per 100 c ft)

Labour. Coolie as. 7 a day, boy as 4 a day.

The Cost of the Bricks and tiles is exclusive of the initial expenditure on Brick and tile machines and other subsidiary nt, also exclusive of the cost of supervision and other overhead charges

cle.	Dimensions.	Weight of one lb.	Mixture used.	% of vol. of water to total vol. of materials	Per 1,000										Daily Out put by one coolie & 2 boys as. 7 & as 4 wages each	Total Cost per 1000 Rs.
					Cement reqd. lbs.	Local Sand reqd. lbs	Local Balst reqd lbs	Good Sand reqd lbs	Cost of Cement Rs	Cost of Local Sand Rs	Cost of Balst. Rs.	Cost of Good Sand	Cost of Labour	Waste & other materials Colour, oil, etc.		
s d).	9″ × 4½″ × 3″	8½	1 : 3 : 5 cement local sand & blst.	11·4%	776	2,585	4,870	..	19·05	1·85	1·85	..	0·8	0·23	900	23·78
ed ng s [	15½″ × 10″ × ½″ thick.	6½	1 : 2	13·5%	1,775	..	..	4,182	43·5	.	.	4·33	7·3	1·6	98	56·23
.	do.	6½	1 : 3	14%	1,530	.	.	5,480	37·6	..	..	5·7	7·35	1·5	90	52·15
ng s 2	15½″ × 9½″ × 1″ thick in middle.	6½	1 : 2	13·5%	1,760	..	.	4,180	43·2	..	..	4·29	7 3	1·6	98	56·39
o. e ing s	do.	6½	1 . 3	14%	1 530	..	.	5,480	37·6	.	..	5·7	7·35	1·5	90	52·15
	15½″ × 9″ × ½″ thick.	6½	1 . 2	13·5%	2,100	..	.	5,050	51·5	..	..	5·2	7·4	1·6	95	65·7

ıcle.	Dimensions	Weight of one lb.	Mixture used	% of vol. of water to total vol of materials	Per 1,000. Cement reqd lbs	Local Sand reqd. lbs	Local Blst reqd lbs	Good Sand reqd. lbs.	Cost of Cement Rs	Cost of Local Sand Rs	Cost of Blst.	Cost of Good sand	Cost of labour	Waste & other materials Colour, oil, etc	Daily Out put by one Coolie & 2 boys as 7 as 4 wages each.	Total Cost per 1,000 Rs
ge ofing ss.	15¾″×9″ ×¾″ thick.	6½	1 3	14%	1,680	.		6,000	41·1	.	.	6·2	7 35	1·5	90	56·15
r ss o- ed	8″×8″ ×1″	5	1 : 3	13%	1,025	..	.	3,660	25 2	..	..	3·8	4·0	·3	175	33·3
	6″×6″× 1½″	2⅞	1 . 3	13%	402	..	..	1,434	9·88	..	..	1·48	3·0	·3	250	14·66

Note —For 1000 roofing tiles, 5 lbs of red oxide is required whith costs about annas 8 10 lbs. of Crude Oil for 1000 pallets cost annas 6 only.

These costs are included in the above figures under other materials column

TABLE No. 3.

"CONCRETE BALUSTRADE"

Details of Quantities, Output and Costs.

For the purpose of these experiments the following prices were assumed.

Cement at Rs. 55 per ton. Sand at Rs. 2-5 per ton (Rs 9 per 100 c ft.)

Ballast at Re. 0-13-6 per ton (Rs 4 per 100 c. ft.)

Labour : Coolie at as. 7 a day, boy as. 4 a day and mason Re. 1-2 a day.

The cost of the balustrade is exclusive of the initial expenditure on moulds and other subsidiary plant, also exclusive ıe cost of supervision and other overhead charges

ırticle	Dimensions	Weight of one lb	Mixture used	% of vol of water to total vol. of materials	Per 100								Daily Output by 2 coolies and 1 mason	Total Cost per 100 Rs.
					Cement reqd lbs	Sand reqd lbs	Ballast reqd. lbs	Cost of Cement Rs.	Cost of sand Rs.	Cost of Balst Rs	Cost of labour Rs	Reinf. & Waste 1 %		
ıstrade ımns ıare Fig).	29½″×5″ sq top 7″ sq. bottom.	52½	1 . 3	14·9%	1,156	4,100	..	28 4	4 23	.	3·6	·33 +4·1	19	40·66
Do.	do.	51	1 : 4	14%	920	4,300	..	22 6	4·43	..	3 6	4·43	19	35·06
o. Round	15½″×4½″ dıa top & 6″ dıa bottom.	29	1 : 3	14 8%	600	2,000	.	14·75	2·06	..	3·0	4·43	21	24·24
Do.	do.	28	1 : 4	14%	450	2,080	..	11·06	2·14	..	3·0	4·43	21	20·63
strade tom ls Fig 3	39½″×12″× 4½″	164	1 : 2 : 3	18%	2,100	4,950	7,524	53 0	5·12	2·86	10 1	1 0	9	72·08
Rail 3 (*c*).	39½″×8″×4½″	80	1 . 2 . 3	18%	935	2,250	3,225	22·5	2·32	1·225	8·5	·82	11	35·36
strade estal. . 3 (*d*).	4′-0″×22″ sq ×3″ approx.	795	1 . 2 : 3	19%	9,640	25,300	37,100	237	26·1	14·05	150	·94	(Concreting 1st day and plastering 2nd day)	524·15

TABLE No. 4.

"CONCRETE FLOWER VASES" & "WATER TROUGHS."

Details of Quantities, Output and Costs

For the purpose of these experiments the following prices were assumed.

Cement at Rs. 55 per ton. Sand at Rs. 2-5 per ton. (Rs 9 per 100 c ft)

Ballast at Re. 0-13-6 per ton (Rs. 4 per 100 c ft)

Labour : Coolie at as. 7 a day, boy as. 4 a day and mason Re. 1-2 a day.

The cost of the balustrade is exclusive of the initial expenditure on moulds and other subsidiary plant, also exclusive e cost of supervision and other overhead charges

rticle	Dimensions	Weight of one lb.	Mixture used.	% of vol. of water to total vol. of materials	Per 100.								Daily Output by 2 coolies & 1 mason	Total Cost per 100 Rs.
					Cement Reqd. lbs.	Sand Reqd. lbs.	Balst Reqd lbs	Cost of Cement Rs.	Cost of Sand Rs.	Cost of Balst. Rs.	Cost of labour Rs	Reinf. & waste 1 % Rs		
wer Vase iout dles. 3.	14″ dia. 13″ high	43	1 : 3	13%	928	3,300	..	22·81	3·4	.	8·5	1·1	11	35·81
Do. ..	do. ..	41	1 : 4	14·5%	880	4,000	..	21·3	4·12	..	8·5	1·1	11	35·02
er Vase ı handles 3.	7½″ dia. 13″ high	31	1 : 4	14·5%	463	2,250	.	11·4	2·32	..	7 6	1·1	13	22·42
Do. ..	do. ..	32	1 . 3	13%	475	2,200	..	11·7	2·27	..	7·6	1 1	13	22 67
rete rec- ;ular gh.	24½″×12″×9″ high inside dia. 1″ thick.	102	1 : 2 : 3	18%	1,385	3,200	4,800	34·0	3 3	1·82	5·1	1·0	Concreting 1st day and plastering 2nd day.	45 22

ESTIMATED COST OF LABOUR AND MATERIA FOR 100 R. FT. OF BALUSTRADE.

(Fig. 3.)

1 Section of 15′-1½″ length centre to centre of pedestals c sists of 4 panels each of 3 columns length, *i e.*, in the section th are 12 columns, 4 bottom and 4 top rails (each rail for 3 colum 1 pedestal and 1 flower pot, ½″ rod runs through holes in rails to hold various panels together.

Cost	1 Pedestal	Rs.	5.240
	1 Flower Pot	,,	0.358
	4 Bottom Rails	,,	2.883
	4 Top Rails	,,	1.414
	12 Columns	,,	4.879
	½″ rod of 15′-1½″ length ..	,,	0.835
Cost of Section of 15′-1½″ length ..		,,	15.609
Cost for 100 ft. length		,,	103.26
Total cost of labour and materials for 100 R. Ft. of Balustrade ..		,,	104 approx.

Fig. 1.

Section of Curved Roofing Tile.

Fig. 2.

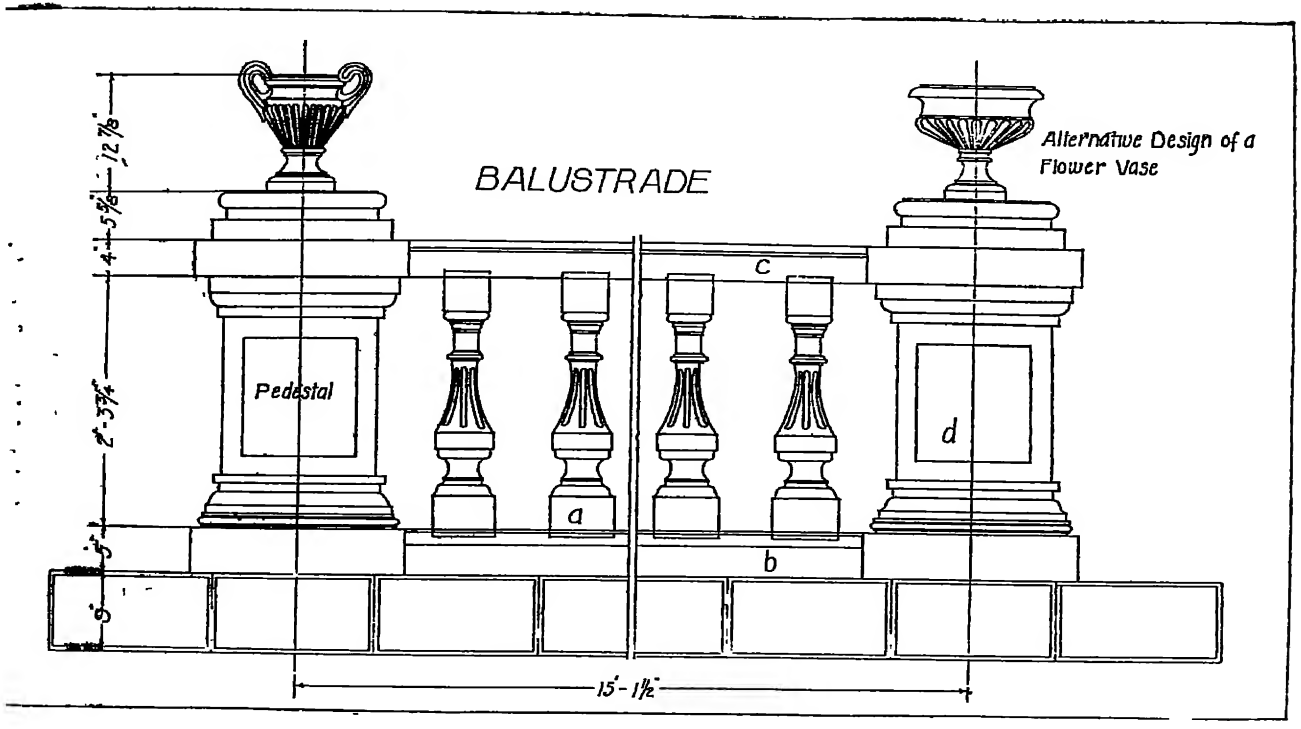

BALUSTRADE
Alternative Design of a Flower Vase
Pedestal
a
b
c
d
1'-3"
2'-3¾"
4'-5⅝"
12⅞"
15'-1½"

Fig. 3.

CHAPTER VI.

TABLES AND MEMORANDA

Cement.

One bag of cement manufactured in India contains 110½ lbs. net.

Twenty bags cement gross weight = 1 ton

One bag of cement manufactured in U.S.A. contains 94 lbs. net.

1 c. ft. of Portland cement weighs from 75 to 90 lbs. when loosely filled into a box without shaking and about 110 lbs. when tightly packed.

It is customary to adopt the weight of cement at 90 lbs. as a basis of comparison when calculating the weight of 1 c. ft. This basis has been adopted by the London County Council and the Royal Institute of British Architects.

One bag of cement of Indian Manufacture is generally assured to contain 1·2 c. ft.

Water.

1. c. ft. of fresh water weighs 62·4 lbs. = ·037 c. yds.

1 Imperial gallon of " " " 10 lbs. = ·16 c. ft.
= 277·46 c. in

1 c. ft. of salt water weighs 64 lbs.

35 c. ft. of salt water weighs 1 ton

1 Imperial gallon equals 1·2 U.S. American gallons.

Concrete.

The average weight of 1 2 : 4 concrete using Coke Breeze as Coarse Aggregate = 100 lbs. per c. ft.

Clinker	"	"	= 110	"
Brick	"	"	= 125	"
Lime stone	"	"	= 135	"
Trap rock	"	"	= 140	"
Gravel	"	"	= 145	"

The weight of " Reinforced Concrete " usually taken for purposes of calculations = 150 lbs. per cu. ft.

Strength of Ordinary Portland Cement Concrete.

The safe compressive strength of 1 : 2 : 4 concrete made with hard broken stone or gravel as coarse aggregate = 600 lbs. per sq.

The crushing strength of concrete made with modern cement and good materials at 28 days old may be 4,000 lbs. per sq. inch or even higher.

Reinforcement.

The ultimate strength of mild steel in
tension = 60,000 lbs per sq. inch
= 27 tons per sq inch

The safe stress for mild steel in
tension = 16,000 lbs per in.
= 7 tons per sq. inch.

Table for estimating reinforcing bar lengths required for Hooks and bends and stirreps.

SIZE OF BARS		½" TO 5/8"	¾" TO ⅞"	1"	1⅛" TO 1¼"
X		X + 1'-0"	X + 1'-2"	X + 1'-4"	X + 1'-6"
90° Bends, Over All	9¾" TO 13¾"	X + 1'-5"	X + 1'-7"	X + 1'-9"	X + 1'-11"
	14¾" TO 18¾"	X + 1'-7½"	X + 1'-9½"	X + 1'-11½"	X + 2'-1½"
	19¾" TO 23¾"	X + 1'-10"	X + 2'-0"	X + 2'-2"	X + 2'-4"
	24¾" TO 28¾"	X + 2'-0½"	X + 2'-2½"	X + 2'-4½"	X + 2'-6½"
	29¾" TO 33¾"	X + 2'-3"	X + 2'-5"	X + 2'-7"	X + 2'-9"
45° Bends, Over All	9¾" TO 13¾"	X + 1'-10"	X + 2'-0"	X + 2'-2"	X + 2'-4"
	14¾" TO 18¾"	X + 2'-3"	X + 2'-5"	X + 2'-7"	X + 2'-9"
	19¾" TO 23¾"	X + 2'-8"	X + 2'-10"	X + 3'-0"	X + 3'-2"
	24¾" TO 28¾"	X + 3'-1"	X + 3'-3"	X + 3'-5"	X + 3'-7"
	29¾" TO 33¾"	X + 3'-6"	X + 3'-8"	X + 3'-10"	X + 4'-0"

X — X: X + 6" FOR 3/16 & ¼" ; X + 8" " ⅜ & 7/16"

JOGGLES: 2" TO 3" ADD 1"

STIRRUPS: 2 X + 2 Y + 5½" FOR 3/16 & ¼" ; 2 X + 2 Y + 7½" = 5/16, ⅜ & ½"

SIZE OF ROUND BAR	¼"	5/16	⅜	½"	5/8"	¾"	⅞"	1"	1⅛"	1¼"
AREA	049	077	110	196	307	442	601	·785	·994	1·227
WEIGHT PER FT	167	261	375	667	1·043	1·502	2·044	2·670	3·379	4·173

Weights and Areas of Steel Bar Reinforcement.

Weight of steel taken as 14 lbs. per sq. ft. 1 in. thick.

Side of Square or Diameter in inches	Square.			Round.		
	Lbs per ft.	Lineal ft. in 1 cwt	Sect area in sq inch.	Lbs per ft	Lineal ft. in 1 cwt.	Sect. area in sq. inch.
¼	·22	524	062	17	667	·049
5/16	·34	336	097	·26	428	·076
⅜	·48	233	140	·38	297	·110
7/16	·66	171	·191	·52	218	·150
½	·86	131	·250	·67	167	·196
9/16	1 08	104	·316	·85	132	·248
⅝	1·33	84	·390	1·05	107	·306
11/16	1·61	69	·472	1·27	88	·371
¾	1 92	58	·562	1·51	74	·442
13/16	2·26	49	660	1·77	63	·518
⅞	2·62	43	·705	2·05	54	·601
15/16	3·00	37½	·879	2·46	45	·690
1	3·42	33	1·000	2·68	42	·785
1⅛	4·33	26	1·265	3 39	33	994
1¼	5·34	21	1·562	4·19	27	1·227
1⅜	6·46	17½	1·890	5 07	22	1·485
1½	7·69	14½	2·250	6 04	18½	1·767

Materials for 1 C. Yard Concrete.

Based on loose cement weighing 90 lbs. per cubic foot with an average specific gravity of 3·12 and a cubic foot of loose moist coarse sand weighing 89 lbs when dried.

Proportions.	Kind of coarse material	Lbs. Portland cement in 1 c yd.	Sand c. yd in 1 c. yd	Coarse Material c yard in 1 c yd
1 1½ . 3	Shingle (40% voids)	666	0 41	0·82
Do.	Broken stone (45% voids)	697	0·43	0 86
1 1⅔ . 3½	Shingle	610	0·42	0 84
Do.	Broken Stone	640	0·44	0·88
1 . 2 4	Shingle	520	0·43	0·86
Do.	Broken Stone	548	0·45	0·90
1 : 2½ 5	Shingle	430	0·44	0·88
Do.	Broken Stone	450	0·46	0·92
1 · 3 · 6	Shingle	364	0 45	0·90
Do	Broken Stone	383	0 47	0·94
1 : 4 8	Shingle	280	0·46	0·92
Do.	Broken Stone	294	0 48	0·97

Classes of Concrete for different degrees of Exposure.

Class of Concrete (Expected Strength at 28 days lb. per sq. in.)	Maximum Quantity Mixing water per sack of cement. Gallons	Type of Structure or Degree of Exposure.
3,000	6	Roadways, piles, pressure pipe and tanks. Thin structural members in severe exposure. Walls, dams, piers, etc., where exposed to severe action of water and frost.
2,500	6¾	Sewers, bridges, walls, dams, piers, etc., for all weather conditions and moderate action of water and frost.
2,000	7½	Ordinary enclosed reinforced concrete buildings. Bridges and retaining walls of heavy sections in moderate exposure.
1,500	8¼	Mass concrete, basement walls, etc., protected from water of servere weather conditions

Free water or moisture carried by the aggregates must be included as

WEIGHTS OF MATERIALS.

	Lb per c ft
Aluminium	162
American Ash	38
Ashes (loose)	40
Asphalt	144
Ballast and sand dry, loose	90 to 106
Ballast and sand, well shaken	99 to 117
Ballast and sand thoroughly wet	120 to 140
Bell metal	502
Bitumen	87
Brass, cast	504
Brick, best pressed	*150
Brick, fire	*137
Brick, common hard	*125
Brick, soft, inferior	*100
Brickwork, pressed brick in cement	140
Brickwork, ordinary	116
Cement, loose from sacks	75 to 90
Chalk	112
Clay, in lump, loose	63
Clay, solid	120
Coal, solid	82
Coal, broken, loose	52
Coke, loose	50
Concrete (Ballast or Gravel)	140
Concrete (Breeze)	90
Concrete (Brick)	112
Concrete (Reinforced)	150
Copper, cast	537
Copper sheet	550
Earth, common loam, dry, loose	76
Earth, common loam, dry, moderately, rammed	95
Earth compacted	136
Earth, as a soft, flowing mud	108
Elm, dry	35
Flint	*162
Glass, common window	157
Glass (Sheet and Plate)	155-175
Grain, at 60 lb. per bushel	48
Granite, Scotch	*164
Gravel, common, loose	109
Gun-metal	528
Hay	5
Hay, pressed	8
Hemlock, dry	25
Iron, cast	450
Iron, wrought	480
Ironstone (Cleveland)	135
Iron ore (Spanish)	150
Iron ore (Swedish)	230
Lead	710
Lime slaked	25 to 37
Limestone	*168
Macadam	150
Marble	175
Masonry, dressed granite or limestone	*165
Masonry, dressed rubble set in mortar	154
Masonry, dressed rubble, dry	*138
Masonry, dressed sandstone	*143
Mortar hardened	103
Mud, dry, close	80 to 110
Mud, wet, fluid, maximum	120
Oak, dry*	59
Oil (Fuel, lubricating, and linseed)	56
Petrol	42
Pumice stone	57
Pine, white, dry	25
Pine yellow	34 to 45
Pine pitch	65
Pitch	77
Plaster of Paris cast	80
Quartz	*165
Quicklime, ground, loose or in small lumps	53
Quicklime, ground, loose thoroughly shaken	75
Red Lead	557
Salt loose	50 to 70
Salt, solid	133
dry, loose	89 to 106
Sand, pure quartz, perfectly dry, slightly shaken	92 to 110
Sand, natural, dry, maximum	117
Sand, thoroughly wet, voids full of water	118 to 120
Shale	162
Slag (Broken)	90
Slate	175
Snow, freshly fallen	5 to 12
Snow, moistened and compact-	

	Lb per c ft.
Spelter or zinc	440
Spruce, dry	25
Steel	490
Stone, Bath	*122
Stone, Basalt	*164
Stone, Kentish rag	*165
Stone, Portland	*148
Stone, Sandstone	*137
Stone, Traprock	*169
Tallow	58·6
Tar	77
Terra-Cotta	112
Tile	113
Timber (Construction)	42
Tin	406
Water, pure, at 39 2°F. or 4°C (for basis of determining specific gravity)	62·425.
Water, rain, at 60°F	62·3
Water, sea (salt)	64
Zinc	438

*These weights are for solid materials, not crushed or broken; allowances must be made for the weights of broken materials varying with the percentage of voids Green timbers weigh ⅛ to ⅓ more than dry

USES OF PORTLAND CEMENT.

ABUTMENTS
- Bridge.
- Dam
- Trestle.

AERATORS
ALTARS.
AMPHITHEATRES.
ANCHORS.
- Buoy.
- Bridge
- Post.

ANVIL BLOCKS.
APPROACHES
- Barns.
- Bridges

AQUARIA
AQUEDUCTS
ARBORS.
ARCHES.
AREAWAYS.
ART STONE.

BALCONIES.
BALUSTRADES.
BAND STANDS.
BARGES.
BARNS.
BARRELS
- Cement
- Coal
- Grain
- Lime.
- Ore.

BARRIERS.
BASE BOARDS.
BASINS.
BEACONS
BEAMS
BEEHIVES
BENCH STANDARDS.
BENCHES.
BENCH MARKS.
BIRD BATHS
BIRD HOUSES
BLACKBOARDS
BLEACHERS.
BLOCKS
BOAT LANDINGS.
BOATS
BOILER SETTINGS.
BOOTHS
BOXES.
- Coffin
- Cooling
- Feed.
- Flower
- Harbage
- Letter.
- Street-Cleaning.
- Water Meter

BRACKETS.
- To support Brackets.

BREAKWATERS
BRICK
BRIDGES
BOUNDARY MARKERS.
BOWLING ALLEYS.
BUILDINGS OF EVERY DESCRIPTION.
BUMPERS
- Filled with Concrete
- for Automobiles

Railroad.
BUOYS

BUTTS FOR TRANSMISSION POLES.

CAISSONS.
CANALS.
- Irrigation.
- Waterpower
- Waterway

CAPS, Chimney.
CARS, FREIGHT.
CATCH BASINS
CATTLE GUARDS
CEILINGS
CELLS, PRISON.
CELLARS
CEMENTATION OF ROCK FISSURES.
CEMETERIES.
- Grave Markers.
- Monuments
- Mortuary Chapels.
- Rubbish Boxes.
- Vaults.

CHANNELS.
CHECK GATES.
CHIMNEYS.
CHUTES.

CISTERN COVERS
CISTERNS.
COAL POCKETS.
COAST DEFENSE
COFFERDAMS.
COLD FRAMES.
COLUMNS.
- Column Footings.

CONCRETE ENCASING
- Clay Sewer Pipe.
- Iron Turbines.
- Segmental Vitrified
- Slay Blocks.
- Steel Bridges.
- Steel Columns
- Steel Girders
- Steel Penstocks.
- Steel Pipes.
- Steel Poles.
- Steel Gasoline Tanks
- Steel Viaducts.
- Wood Piles.
- Wood Poles.

CONDUITS.
- Telephone.
- Water.

COPING.
CORNCRIBS.
CORNICES.
COUNTERWEIGHTS
- Bridge.

COURTS.
- Croquet.
- Tennis

CURBS
CURTAINS
DAMS.
DECORATIVE.
- Bridges
- Buildings
- Cemeteries
- Gardens
- Parks

DIPPING VATS.
DOCKS
DOMES.
DOOR FRAMES
DRAIN HEADS.
DRAIN TILE.
DRIP AND SPLASH BOARDS FOR TANKS.
DRIVEWAYS
DRY DOCKS.

ENGINE BEDS

FACING
- Block
- Bridge
- Building
- Dams
- Reservoir.

FACTORIES
FENCES.
FILTERS
- Sewage.
- Water Purification.

FIRE PLACES.
FIREPROOFING.
FIRE WALLS
FLAG POLES
FLOOD PREVENTION.
FLOORS OF ALL KINDS.
FLOWER POTS.
FLUMES.
FONTS.
FOOT SCRAPERS.
FORGES
- Blacksmith.

FORTIFICATIONS.
FORUMS.
FOUNDATIONS.
FOUNTAINS.
- Drinking.

FRAMES.
- Art Window
- Door.
- Partitions and Wall.
- Opening.
- Transom.
- Window

FROST PROOFING.
FURNITURE.
- Garden

GARAGES.
GARGOYLES.
GATE CHAMBERS
GIRDERS.
GRANDSTANDS
GUARD RAILS.
GUTTERS

HARBOR CONSTRUCTION
HEAD GATES
HENS' NESTS
HOG WALLOWS.
HOT BEDS
HOUSES.

ICE BOXES
INCINERATORS
  Garden Refuse
  Garbage.
INLETS
  Flume
  Sewer
  Insulation
IRRIGATION CONDUITS.

JETTIES

KENNELS.

LAWN ROLLERS
LAUNCHING WAYS
LINING.
LINTELS
LOCKS, CANAL
LUMBER, CONCRETE

MANGERS
MANHOLES
MANTLES.
MARKERS, BOUNDARY.
MASONRY
MILL RACE.
MINE CONSTRUCTION.
MOIST CABINETS.
MONUMENTS.
MORTAR
MOSAIC DECORATION
MOULDINGS.

ORGAN PIPES
OUTLETS.
  Channel
  Sewer.

PAINT.
PANELS, FENCE.
PAVEMENTS.
PERGOLAS
PIERS.
PILES.
PIPES.
  Ash.
  Boiler.
  Engine
  Fertilizer.
  Manure.
  Motor.
PLATFORMS.
POLES
PONDS.
POOLS
  Bathing.
  Wading
PORCHES.
POSTS
  Anchor
  Arbor.
  Clothesline.
  Fence
  Gate.
  Hitching
  Mail Box
  Mile.
  Sign.
  Signal.
  Vineyard
POWER PLANTS
PROTECTION OF
  Iron.
  Steel
  Wood
PUMPING PLANTS.

QUAYS.

RATPROOFING.
REFRIGERATORS.
REMODELING.
RESERVOIRS.
RETAINING WALLS.
REVETMENTS.
ROADS.
ROOFS.
RUNWAYS.

SAFETY ISLES AT STREET CROSSINGS.
SEWAGE DISPOSAL
SEWERS
SHAFTS.
  Elevator
  Mine
  Tunnel.
  Sheds
SHINGLES.
SIDEWALKS.
SIGNS.
  House Number
SILLS FOR WINDOWS.
SILOS.
SINKS.
SIPHONS.

SLEEPERS, FLOORS.
  Railway.
SLUICEWAYS.
SMELTERS
SPEEDWAYS.
SPILLWAYS
STADIA.
STAIRWAYS
STUCCO
SUBWAYS
SUN-DIALS
SWITCHBOARDS.
SYNTHETIC STONE.

TABLES
  Billard.
  Laboratory.
TABLETS, MEMORIAL.
TANKS.
TIES, RAILROAD.
TILE
  Decorative.
  Drain.
  Tourist Camps.
TOY BLOCKS.
TREE SURGERY.
TREE GUARDS.
TRIMSTONE.
TROUGHS, DRINKING.
TRUSSES.
TUBS.
TUNNELS.
TURNTABLES.
TURPENTINE CUPS.

URNS.

VASES.
VATS.
VAULTS.
  Bank
  Battery.
  Burial
  Safety.

WAITING STATIONS.
WALLS
WAREHOUSES.
WATER COOLERS.
WATERPROOFING.
WATER WORKS SYSTEMS.
WELLS.
  Gas.
  Oil.
  Water.
WHARVES.

BIBLIOGRAPHY.

BOOKS RELATING TO CONCRETE WORK..

Subject.	Title	Author	Publisher	Price	Date of publication.	Review
idges.	Reinforced Concrete Construction Vol. III Bridges and Culverts	G. A Hool	McGraw Hill Book Co. Inc. 239, West 39th Street, New York or 6 & 7, Bouverie Street, London, E C 4	Rs 26/4	1916	Includes Chapters on General Data. Deflection of curved beams. Analysis of symmetrical arch by Elastic theory Details of Arch bridge construction Slab and Girder bridges, Culverts Construction Plant Artistic design, etc
Do	" Reinforced Concrete Part I Methods of Calculation	A. W Buel and C S. Hill	Do	Rs 26/4.	1906	Includes chapters on R C Bridges design
Do	Concrete Bridges		The British Portland Cement Association London	Rs 18/6		Contains notes on the use of concrete bridges with illustrations of most important concrete bridges of the world.

Do. ..	Reinforced Concrete Bridges.	F. Rings ..	Constable & Co. Ltd London	Rs 18/0	1913	Includes chapters on Bending moments, Stresses, Strains, Loads on bridges, External Stresses, Culverts, Coverings, Tunnels, etc Beam Bridges, Calculation of Girdar Bridges and Worked Examples, Examples of Girder Bridges, Design of Arched Bridges and Abutments. Theory of the Arch and examples of Arch bridges. Formuæ, Notes, Schedules, and other useful information.
lding Con-truction.	A.B.C. of Plastering.	A. H. Telling ..	Oxford University Press.	Rs. 7/7.	1927	Deals with the History of Plastering and explains terms used in the trade, etc.
Do. ..	Concrete Cottages Bungalows and Garages (Second Edition).	Albert Lakeman	Concrete Publications Ltd., London.	Paper Rs. 3/1. Cloth. Rs. 4/6.	1924.	Contains chapters on general principles of construction, in Situ Work, Blocks, Designs for Cottages and Bungalows, Designs and Construction of Garages, General information for the builder, alternative methods of construction and machinery for construction
Do ..	Concrete Building Construction.	T Crane and T Nolan.	John Wiley & Sons.	Rs. 26/4.	1927	Presents in simple, practical form the general accepted principles of concrete design as applied to buildings together with recommended methods of office procedure of field construction.

Subject.	Title	Author	Publisher	Price	Date of publi-cation.	Review.
ilding Con-trhotion.	Concrete for House Farm and Estate	F Ballard .	Crosby Lockwood & Son	Rs 6/9	1925	Intended to help the Estate Manager, Builder, Brick Layer and even the Labourer Gives some examples of works that have been carried out successfully
Do. .	Concrete House .	G W. Hilton .	E and F N Spon London and Spon and Chamberlain, New York	Rs. 1/5	1919.	An explanatory treatise on how the author during the war time largely by his own labour erected and completed a detached two storied mono block concrete house designed for his own occupation
Do .	Materials of Concruction as used in India Vol I & II	N N Mitra	Thacker Spink & Co , Calcutta and Simla	Rs 20	1924	Vol I Deals with Materials of Construction, their nature, production and use Vol II deals with Metals.
ient	Cement, Limes and Plasters.	E. C. Eckel	John Wiley & Sons, N.Y. Chapman & Hall, London.	Rs 28/7	1922	Includes Chapters on Chemical composition of cement and the chemistry to manufacture
Do.	Cement Concrete and Bricks.	A B Searle	Constable & Co .	Rs 21.	1926	Contains raw materials for Cement, methods of manufacture, chemical and physical changes, in-setting and hardening Testing, Components of concrete R. C. Concrete, etc.

crete Mak- ig.	Concrete Practice ..	Hool and Pulver.	McGraw Hill Book Co	Rs 13/2.	1926.	This is a text book for vocational and training schools Includes a great deal of very useful knowledge for the Engineer
ign ..	Concrete Plain and Reinforced Vol. I Theory and Design of Concrete and R. C. Structures	Taylor, Thompson and Smulski	J. Wiley & Sons, N. Y. and Chapman & Hall Ltd, London.	Rs 35	1925	Comprehensive Treatise for both practical Engineer and Students
)o. ..	R. C. Practical Hand Book.	R. J. Harrington Hudson.	Chapman & Hall Ltd.	Rs 14	1922	The object of this handbook is to explain in a simple manner the theory of R. C and to furnish, tables, charts, data and other items of information in designing.
)o. ..	Principles R. C. Construction.	Turneaure and E. R. Maurer.	J. Wiley & Co, N. Y and Chapman & Hall	Rs 17/8	1919.	Includes chapters on designs of beams, columns, slabs, arches, retaining walls and dams, R C. chimneys, etc
)o .	R C. Treatise ..	W Noble Twelve trees	Sir Isac Piman & Sons Ltd., London.	Rs 18/6	1920	Includes chapter on Standard Notation for Engineering Formulæ by E. Fiander Etchells
)o. ..	R C Design, Introduction to	H Sutherland and and W W Chifford	Chapman & Hall Ld and J. Wiley & Sons	Rs 17/8	1927	Presents fundamentals of R C. design as simple and completely as possible The method of transform section for the development of the theory Includes chapters on Concrete Materials, Beams, Compression Members, Retaining walls, Bridges, Building design, arches, etc.

Subject	Title.	Author	Publisher.	Price.	Date of publi. cation.	Review
ɜn. ..	R C. Design (Vol. 1) Theory.	O. Faber and P G. Bowie.	Ed. Arnold & Co, London	Vol. 1. Rs. 12/4	1924.	Vol. I. Theory including chapters on general principles, materials calculations, Bending adhesive and shear, columns, beams and slabs, reservoirs and retaining walls Specifications. Quantities, etc
). .	R. C. Design Vol. II Practice.	Do. ..	Do. ..	Rs. 15/12	Do	Vol. II Practice. Contains chapters on Bending Moments in continuous Beams, Moments in Columns, Building regulations, etc
). ..	Elementary Guide to R. C. Concrete	A. Lakeman .	Concrete Publications Ltd., London	Rs. 1/12	1925	A simple explanation on R C Design and Construction for the Student Clerks of Works, Foreman and others
). ..	R. C Concrete Explained.	O. Faber .	Oxford University Press, London.	Rs 6/4	1926	Written for the Comparitively non-technical reader with examples and method of calculations simply explained
). ..	Simple Examples of R C. Design	O. Faber .	Oxford University Press	Rs. 4,6.	1924	Contains examples of elementary calculations for circular water tanks, slabs, beams, columns, water towers, etc.

). ..	R. C Beams in Bending and Shear Theory and Tests of Support.	O. Faber ..	Concrete Pubhcations Ltd	Rs. 7/14	.	Being a development to the Author's theory in regard to Shear and the experimental researches on which it is based together with theory and researches in beams in bending.
).	Elementary Treatise on R.C. Construction	E. S. Andrews .	Scott Greenwood & Son, E. C. 4	Rs. 6/9	1924	Text Books for Students, Engineers and Architects
gn	R. C. Railway Structures.	J. D. W. Ball .	Constable & Co, Ltd, London	Rs. 7/14	1913	Describes the generally accepted principles and processes upon which the design and construction of R. C Structures depend and more especially those structures which come within the practice of the Railway Engineer
). ..	Architectural Design in Concrete.	T P. Bennett .	Ernest Benn Ltd, London	Rs 26/4	1927	The Author in an introduction briefly reviews the trend of architectural design in concrete over the past centuries and demonstrates how development has been made This book is full of beautiful illustrations
.	The properties and Design of Reinforced Concrete.	N. Martin .	Constable & Co. Ltd	Rs. 7	1912.	Contains Instructions Authorised Methods of Calculation, Experimental Results and Reports by the French Government Commissions on R. C.

ubject.	Title.	Author.	Publisher	Price	Date of publication.	Review
.	A Concise Treatise on Reinforced Concrete.	C. F. Marsh ..	Constable & Co. Ltd London	Rs. 10/15	1920.	Contains chapters on Properties, Behaviour under Loading, Methods of Calculation, Methods Reinforcement etc.
.	Practical Designing in Reinforced Concrete	M T. Cantell	E & F N Spon Ltd London	Rs 13/2.	1928	Describes Reinforced Concrete and its suitability for various kinds of structures, together with examples worked out in detail for all types of Beams, Floors and columns.
age ..	Sewage Works ..	F C. Temple ..	Crosby Lockwood & Son, London., and Thackers Spink & Co (India)	Rs 4/6.	1927	Deals fully with Sewerage works Concrete Gutters, Septic Tanks and Filters, Design for sludge tanks, etc.
work and ittering	Design of Form Work.	A. E. Wyn ..	Concrete Publications, Ltd.	..	1926	Includes Chapters on form work building in general. Materials, design of forms, tables, forms for Sewers, dams beams walls, arches, etc.
lbooks and cket Books	Everyday Uses of Portland Cement	..	Cement Marketing Co Ltd , London.	Rs. 6/9.	1921	A useful practical Handbook containing chapters on cement concrete workmanship, Concrete blocks R. C. Concrete, foundations, pipes, sewers, Houses concrete products, etc.

Do. ..	Military Engineer Services Handbook. Vol. I.		Government of India Central Publication Branch, Calcutta	Rs. 6/8	1925	Vol. I Deals with Building and General, Specifications and Structural Design
Do ..	Do. Vol. II ..	.	Do .	Rs 2	1925	Gives details of building design from which suitable types can be selected readily
Do. ..	Do. Vol. III ..	..	Do. .	Rs. 1 9.	1925	Deals with practical requirements of Road Construction and maintenance with special regard to Indian requirements.
Do. ..	Do. Vol. IV ..	.	Do .	Rs. 1/6	1925	Deals with technical mechanical and water supply
Do. ..	Concrete Year Book.	Oscar Faber & H. L Childe	Concrete Publications Ltd.	Rs. 3/1.	1928	Contains chapters on Cement, Essential Factors in making of concrete, tables for R. C. Designs, Water, Towers, Floors, Roads Surface treatment. Memoranda for Concrete Users, etc.
Do ..	P W.D Hand Book Bombay Vol I.	Captain E. L. Marryat	Government Central Press	Reprinti	ng.	Contains chapters on materials Buildings, reinforced concrete and General notes for guidance
Do. ..	Do Vol. II ..	Do. .	Do	Reprinti	ng.	Contains chapters on Roadwork, Roadside Arboriculture Hydraulic Formulæ and Data Drains, Culverts and Bridges Masonry Dams and Retaining Walls.

Subject.	Title.	Author.	Publisher.	Price.	Date of Publication.	Review
inery	Concrete Making Machinery	W. Noble Twelvetrees.	Scot Greenwood & Son	Rs. 7/7.	1925.	Includes appliances and plant for testing and preparing the constituent materials and for the distribution of mixed concrete. Particulars of concrete mixers, screens, crushers and washers Mixing and Distributing machinery, etc.
ucts .	Concrete Products and Cast Stone, Manufacture and use of.	H L. Childe .	Concrete Publications Ltd	Rs 4/6	1927	Deals explicitly with manufacture of cast stone and concrete products and design of moulds
ls ..	The Science of Road Making.	J. W. Green and C N Ridley	Crosby Lookwood & Son	Rs 9/3	1927	Treatise on the more technical side of Road Construction
.	Concrete Roads	..	Concrete Publications Ltd	Rs 4/6.	1923	Gives description of the Concrete Roads in the United Kingdom together with a summary of the experience in this form of construction gained in Australia, Canada, New Zealand and the United States of America
..	Road Engineering	E. E Leemings ..	Constable & Co Ltd	Rs.15/12	1924	Treats in a concise form the technology of road construction in the light of the new conditions created by modern traffic.

						in the construction and maintenance of roads and footpaths
..	Highway Materials	E. E. Bauer .	McGraw Hill Book Co. Inc , London	Rs 15/5.	1928	Contains descriptive matter concerning the qualities, specifications and interpretation of test results in addition to the portions discussing sampling and test of Highway materials
..	Principles of Highway Engineering.	C C Wiley .	McGraw Hill Book Co , Inc London.	Rs. 17/8	1928	

PERIODICALS.

Title.	Office of Publication	Price	Issued
INDIAN.			
Hume Pipe News.	The Indian Hume Pipe Co Ltd , Phœnix Building, Ballard Estate, Bombay	Free	Monthly
" Indian Concrete Journal."	The Concrete Association of India, Telephone Bldg Home Street, Bombay	As. 8 ' per copy Rs 5 per year. Post free	Monthly
" Indian Engineering."	7, Mission Row, Calcutta	Yearly Rs 24.	Weekly.
ENGLAND			
" Concrete and Constructional Engineering."	The Concrete Publications Ltd , 20, Dartmouth St , Westminster, S W 1	1*s.* 6*d* per copy. 18*s* per year.	Monthly.
" Concrete for the Builder and Concrete Products "	The Concrete Publications Ltd , 20, Dartmouth St Westminster, S.W. 1.	4*d* per copy	Monthly.
" Contractors Record and Municipal Engineering "	329, High Holborn, London W C 1	9*d* per copy. £2-8-0 per year	Weekly.
" Modern Building Construction— with which is incorporated Road Making "	20, Buckingham Gate, London, S W 1	3*d*. per copy	Monthly.
" The Structural Engineer."	The Temsbank Publishing Co., Ltd., 21, Northumberland Avenue, W C 1.	1*s* per copy	Monthly.
AMERICA.			
" Concrete " ..	Concrete Publishing Co , 139, North Clerk Street, Chicago, 111	$ 4 per year.	Monthly
" Engineering News Record."	McGraw-Hill Publishing Co , Tenth Avenue at 36th Street, New York.	$ 9 per year 25 cents per copy.	Weekly
" Rock Products "	Trade Press Publishing Corporation, 542, South Dearborn Street, Chicago Illinois, U.S.A.	$ 3 per year 25 cents per copy.	Fortnightly.
" The National Sand and Gravel	The National Sand and Gravel Association, Munsey Building Washington	$ 2 per year 25 cents per copy.	Monthly.

THE DIRECTORY

OF THE

CONCRETE INDUSTRY

IN INDIA.

This Directory has been compiled from such information as is at present to hand. It is obviously far from complete and we trust our readers will assist us in bringing and keeping it up-to-date. Information regarding new entries and corrections of existing entries will be welcomed and should be sent to the Concrete Association of India, P. O Box 138, Bombay.

The Directory has been divided into four main sections each of which has many subsections. These four main sections are :—

(1) Engineering.
(2) Materials.
(3) Plant and Machinery.
(4) Concrete Products.

DIRECTORY

OF

THE CONCRETE INDUSTRY OF INDIA.

CONTENTS.

Everywhere throughout the directory alphabetical arrangement has been adopted in order to facilitate reference.

ENGINEERING SECTION.

Architects Specialising in Concrete.

BANGALORE—
LAKSHMI NARASAPPA, S H, Principal, College of Engineering

BARNAGORE—
GOSH, I N, 22, Sashibhusen Neogy Garden Lane, 24 Pergannas

BOMBAY—
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MARTIN & Co., 6 & 7, Clive Street (See page 152)
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KESAVAN, K C.

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HEATLY & GRESHAM LTD., 9, Forbes Street, Fort (See page 149),
MARSLAND PRICE & CO., LTD., Phœnix Building, Sprott Road, Ballard Estate.
MAWSON VERNON CO., LTD., "Vulcan House," Nicol Road, Ballard Estate (See page 153).
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DWARKA-(KATHIAWAR)—
OKHA CEMENT Co , LTD.

JAPLA-(BIHAR.)—
SONE VALLEY PORTLAND CEMENT Co , LTD. (E.I.Rly.) (See page 152).

KATNI-(C.P.)—
KATNI CEMENT & INDUSTRIAL Co., LTD. (G.I.P. Rly.) (See page 131 & 132)

KYMORE-(C.P.)—
CENTRAL PROVINCES PORTLAND CEMENT Co , LTD. C.P. (E.I. Rly.) (See

LAKHERI-(RAJPUTANA)—
BUNDI PORTLAND CEMENT LTD (B B & C I. Rly) (See page 145)
MEHGAON-(C.P.)—
UNITED CEMENT CO OF INDIA, LTD (E.I. Rly) (See page 150).
PORBUNDAR-(KATHIAWAR)—
INDIAN CEMENT CO, LTD, Kathiawar, W I
SHAHABAD-(HYDERABAD STATE)—
SHAHABAD CEMENT CO, LTD, Hyderabad State
WAH (PUNJAB)—
PUNJAB PORTLAND CEMENT LTD, (N W Rly) (See page 149)

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CHAINOMAL DHARAMDAS
CHANDOOMAL GANGARAM, Thana Road
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IRANI RUSTOM, Bruce Road.
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JUGAL CHARAN MALIK.
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BURN & CO., LTD., 7, Hastings Street, Howrah.
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DEY & CO., D. N., 210, Harrison Road.
HARRY & CO., S. D., 200, Upper Chitpur Road, Baghbazar.
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KAVARANA & SON, N. S., 72/1, Clive Street.
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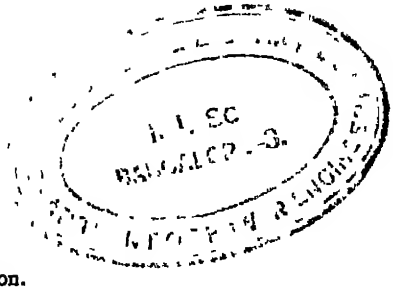

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DEOLALI CAMP—
ALOOMULL JOOBARMULL
ESOOFALLY & SONS
SALEBHOY ESMAILJI
SHIBRAM GUNGARAM.
K. TIKARAM.

N. DEHGAM—
MISTRI MADHAVJI GIRDHERLAL.

DEROL—
PURSOTAM BHAIJIBHAI MEHTA.

DESAR ROAD—
HARILAL GIRDHERDAS

DHARMAJ—
RAVENDAS JAVERBHAI & Co.

DHANDHUKA—
RAJABALLI ABDULHUSAIN.

DHINOJ—
KALIDAS CHHAGANLAL.

DHOLKA—
LAVJIBHAI NARANDAS.

DHULIA—
A. KAYUM, Contractor.
ABDUL KAYUM KAMRUDDIN, Agra Road.
SAJAUDIN FIDALLY & Co., Contractors
VALLAJI MAHOMEDALLY, Agra Road

DOHAD—
MUSEHAI SHAIKH ABDULLABHAI

DWARKA—
HARIDAS VITHALDAS.

GANDEVI—
GULAMHUSSAIN TAYABALLI.

GHANSAMA—
SHIVLAL FULCHAND & CHAGANLAL.
CHATURBHA PATEL.

GHOLY—
AHMED MIYA ABDOOLGUNNY
ROSANALLY ABDOOLHUSEN.

GODHRA—
HUSSANALLI ABDULALLI
VORA ESUFALLY BADRUDIN & BROS

GOJPUR SANKHEDA—
RISKLAL JAGJIWANDAS DESAI

GONDAL—
JIWAJI GULAMHUSAIN.

HALOL—
BHOGILAL VAJUBHAI.

HALWAD—
SAMSUDIN KIKABHAI.

HARIJ—
ABDULHUSAIN JIWAJI.

HIMATNAGAR—
LATIFBHAI VALLIBHAI.

HYDERABAD (Sind)—
HASANALLI & SONS, A.
SALEH MOHD., SHER MAHOMED.
VAROMAL RATANCHAND.

IGATPURI—
ABASBHAY DAWOODBHAY PISHORY.
BHURMULL NUTHMULL.
BUKSHIRAM RAMDHAN.
SHALIGRAM RATANLAL.

ITOLA—
AKBARALLI SARAFALLI.
MOTIBHAI VAGHJIBHAI DESAI.

JALGAON—
ENAETHUSAIN CAMRUDIN, Merchant.
FIDALLY AKBARALI.

JAMBUSAR—
ABDULLA HASANBHAI.

JAMNAGAR—
KADERBHAI ALIBHAI ANGREJ.
LALJI MORARJI.

JETPUR—
AHMED HAJI TYEB.

JHAGADIA—
ESSUFALLI ABDULALLI

JUNAGADH—
ABDULHUSSAIN MULLA
NURUDDIN BHAIJIBHAI
NURBHAI VALIBHAI.

KADI—
LATIFBHAI REHMANBHAI.

KAIRA—
SOMCHAND DHULABHAI SHAH

KALOL—
MISTRI PARBHUDAS VALLABHDAS.
PRANTIK SAMITTEE.

KALYAN—
YUSUFALLY MAHOMEDALLY, Bazar

KAPADVANJ—
KADERBHAI ESUFBHAI.

KARACHI—
DAMODAR KALIDAS, Mithadhar
DHANJI KALIDAS, Jhoona Market
GIDAMAL BHAGCHAND & SONS, Near Khori Garden
GULABCHAND CHATURBHUJ, Ranchore Lines.
HIRJI TRIKAMJI, Khori Garden
KADHIBHOY, M , Jhoona Market.
KARAMSI ODHAVJI, Ranchore Lines
KARSANDAS BHANJI, Jhoona Market
KEWALRAM KISHMAL, Mithadhar
KRISHNA METAL MART, Nanakwara
LALCHAND KISHMAL, Mithadhar
MACDONALD & Co , P. O. Box No. 33.
MAGHANMAL BHAWANJEE, Kanda Gali.
PALLONJI EDULJI & Co , Bunder Road.
PRANJIVAN GOCULDAS, Ranchore Lines.
VISHRAM MEGHJI, Jodia Bazar
VORA TAYABALLI MAHOMEDALLI RANGWALA, Marriot Road

KARAMSAD—
DAHYABHAI MULJIBHAI PATEL

KARVAN—
HAJI NURMOHMED ABBA.

KHERALU—
ABDULHUSAIN HASANJI.

KHODIAR—
GOCULBHAI NARSIBHAI PATEL.

KIM—

KOLHAPUR—
MOHIDDINBHOY MALIKBHOY MANER.

KOPARGAON—
BALAJI GUNGADHAR GUJRATE.
ESUFALLY HAJI TAYEBALLY.

KOSAMBA—
KARIM USMAN

KOTRI—
THUNAMAL BULCHAND.

LIMBI—
KANTILAL KESHAVLAL.

LODRA—
MANILAL JAGJIWAN.

LUNAWADA—
KUTUBJI DOSABHAI

MACCA-KHAD—
NATHUBHAI GANGARAM.

MADHI—
CHUNILAL JAGIVANDAS, Madhi, Tapti Railway.
MAGINLAL NAGINDAS, Madhi, Tapti Railway.
NATHUBHAI BHAGUBHAI & Co., Madhi, Tapti Railway.

MAHUDHA—
GOKALDAS GORDHANDAS.

MALEGAON—
AKBARALLY HYDERALLY

MAHUVA—
KADIBHAI EBRAHIMJI

MANGORAL—
HARJIBHAI RAJAJI, Via Kosamba.

MANMAD—
MULLA ABDOOLHUSEN JAFORJI.
GULAMHUSEN TAYEBALLY.

MANUND ROAD—
KHODIDAS HEMCHAND RANUJ.

MASAR ROAD—
KHIMCHAND HARGOWANDAS.

MEHMEDABAD—
HAJI NANAMIA GULAMMOHIUDIN.

MEHSANA—
DESAI BROTHERS.
VAGHJIBHAI BAVAJI, Contractor.

MIRAJ—
SITARAMDAS JAVARAMDAS SHEDJI.

MIRPUR KHAS—
MULCHAND TILLUMAL.

MIYAGAM—
SAMSUDIN MIYA FRDAHIM

MOBHA ROAD—
MAGANBHAI MOTIBHAI PATEL.
VALLIMOHMED AHMED

MODASA—
CHANDULAL SHANKERLAL.

MOROLI—
METHA & SONS
C. R. DESAI

MORVI—
PIRBHAI NURBHAI

NABIRPUR—
JIJIBHAI GOVINDBHAI PATEL.

NADIAD—
BHAILAL MORARJI RAV.

NANDABAR—
ADAMJI IBRAHIMJI, Nandabar, Tapti Railway.

NANDGAON—
ALLIBHOY EBRAHIMJI, Iron Merchant.

NAR—
MANGALDAS MADHAVDAS

NASIK CITY—
KIKABHOY ABDOOLALLY & BROTHERS.
NEPTULLA HABIBULLA.
MOHAMED BHAI ESUFALLY, 1003, Main Road.
RASULBHAI HUSSONEJI, Bori Bazar.

NASIK ROAD—
AKBERALLY M. MOHOMEDALLY
ALLIHUSAIN KASAMALLY

NAVLAKHI BUNDER—
MISTRI JEKA LAXMAN.

NAVLI—
JAVERBHAI MANORBHAI.

NAVSARI—
CHHAGANLAL BACHERDAS, Kaliyavadi
KAMROODIN RASULJI LOKANDWALA, Bazar.
KAMRUDIN & TAYABALLI, Motabazar
KIKABHAI SULTANALLI, F., Motabazar
MANCHERJI DADABHAI, Motabazar.
NARSIBHAI LALBHAI, Kaliyavadi.
SULAMANJI KIKABHAI & SONS, Motabazar.
YAYDERALLI KAMRUDIN, Motabazar.

NAWABSHAH—
LAKHIRAM RELUMAL.

OKHA PORT—
LAKHIRAM RELUMAL.

PACHORA—
EBRAHIMJI HAJIALIBHOY, Merchant

PADRA—
CHHAGANLAL ASHARAM
MUNVERALLI ABDULHUSAIN.
TYABALLI ESABHAI

PALANPUR—

PALEJ—
HYDERALLI ABDULALLI.

PATAN—
AMBALAL MOTILAL DANI & JETHABHAI MANCHAND GANDHI

PATRI—
NARANLAL TALAKSIBHAI.

PETLAD—
MOTILAL HIRABHAI KACHHIA.

POONA—
ABASSBHOY KADERBHOY, Raviwar Peth.
DINSHAW & Co , F., 80, Main Street
EBRAHIM & Co., 63, Main Street.
JIWANJEE NOORBHOY, Raviwar Peth.
KALBHOR & Co., Near Reay Market
RASHID KHODADAD & Co., 81, Main Street
SATHE, M G., Shukerwar Peth.

PORBANDER—
GIRDHAR HEMRAJ, Bunder Road.
VITHALDAS PURSHOTTAM BHABHA & Co.

RAJKOT—
KADIBHAI MUSAJI.
KAPURCHAND PANCHAND MEHTA

RAJPIPLA—
JEKISONDAS NAROTAMDAS, *Via* Ankleshwar.
MANSUKHLAL MULJIBHAI, *Via* Ankleshwar.

RANDHEJA—
MANUBHAI NALCHAND.

RANOLI—
CHIMANLAL DEVJIBHAI & Co

SANAND—
CHHAGANBHAI CHATURBHAI.

SANDASAL—
PURSOTAM BHOGILAL.

SANGLI—
PANDURAM KRISHNA DANDEKAR.

SANKHEDA—
PRAVILAL OCHHAVLAL.

SAVARKUNDLA—
LALJI VIRCHAND.

SAVDA—
MAHOMEDALLI ALLABUX, Merchant.

SAVLI—
HIMATLAL PURSOTAMDAS.

SAYAN—
AMERSI JETHABHAI.
CHOTABHAI & AHAMADBHAI, Kathor.
MULJIBHAI NARBHERAM, Kathor.

SEWALIA—
RAHIMTULLA RASULBHAI, Balasinor.

SHAHDAPUR—
SEUMAL GIANCHAND.

SHIKARPUR

SHOLAPUR—
NAGAPPA & SONS.
RENDE, G V

SIDHPUR—
DESAI BROTHERS

SINNER—
ABDOOLHUSEN HAJI HIPTUALLA
ABDOOL TAYEB M BADRUDIN.

SOJITRA—
KASUMALLI SHAIKH AKBARALLI
RAOJIBHAI MOTIBHAI PATEL.

SORATH VANTHLI—
EBRAHIMJI VALLIJI.

SUKKUR—
KEWALRAM TECKCHAND & Co.
KOTOOMAL DWARKADAS & Co
URJANDAS DHEROMAL.

SURAT—
ABDULALLI SULAMHUSAN, Kanpith Bazar.
ATMARAM, T, Kanpith Bazar
ATMARAM JEKISONDAS, Kanpith Bazar.
DADUBHAI VALIBHAI, Near Tower.
GOLWALA CHANDULAL NAGINDAS, Main Road
GOOLAMHUSAIN ABDOOLALLI, Clock Tower
HAJI GOOLAMRASOOL GOOLAMALI, Baranpuri Bhagal.
HARILAL & Co, N. T, Haripura
HIRLAL BALOOBHAI, Kanpith Bazar.
ICHHARAM NAROTAMDAS, Navsari Bazar
ISHWARDAS TAPIDAS, Kanpith Bazar.
ISMAIL MAHOMAD ASVAT, Rander
JINABHAI HARKISONDAS, Limda Chowk
KHURBHANHUSAIN KIKABHAI, Kanpith Bazar.
KUBERDAS KALANDAS, Contractor.
MAHOMOD ISMAIL AMLA, Kanskivad.
MANILAL ISVERDAS, Kanpith Bazar
MANJIBHAI DEVJIBHAI, Baranpuri Bhagal
MEHHANLAL GHALABHAI, Kanpith Bazar.
MEHTA & Co, N. M.
MIAKHAN ADAMJI, T. A., Kanpith Bazar
MUGANBHAI TALLOOBHAI, Navsari Bazar.
NATHUBHAI DEVCHAND, Kanpith Bazar
NATVARLAL ZINABHAI, Baranpuri Bhagal
NOORUDDIN ALIBHOY & SONS, Kanpith Bazar.
NOORMAHOMED DOSABHAI.
PESTONJI BARJORJI WARIA, Machlipith
SANTILAL SHAMBHULAL & Co., Kanskivad.
SORABJI N WADIA, Machlipith.
TAYABALLY DAWOODJI, Jhanpa Bazar
THAKORDAS HARKISONDAS, Baranpuri Bhagal.
WADIA, B. F, Baranpuri Bhagal
WADIA, N. B, Baranpuri Bhagal.

TALOD—
HIRACHAND VENICHAND, Harsol

TANDO ADAM—
PURSAMAL RAMCHAND

TARAPORE—
FULABHAI MARGABHAI AMIN.

THANA—
ABDULALI VALIJI.

THASRA—
NATVERLAL GOPALDAS DESAI

TIMBA ROAD—
CHHAGANLAL MOTILAL.

UMRETH—
TEYBJI SULEMANJI

UNJHA—
ISWERBHAI LALCHAND

UPLETA—
TEYBJI SULEMANJI.

URAN—
SIDHWA & CO.

VADNAGAR—
ESUFALLI MOHMEDALLI.

VASAD—
ISWERBHAI PURSOTAMDAS KACHHIA.

VASO—
RAVJIBHAI NARSIBHAI PATEL.

VERAWAL—
GIRDHAR HEMRAJ & CO.

VIJAPUR—
SYEDBHAI KADERBHAI.

VIRAMGAM—
ABDULHUSAIN SAMASJI

VISNAGAR—
SYEDBHAI KADERBHAI.

VYARA—
ABDULRAHAMAN NANUJAN, Vyara, Tapti Railway.
KHUSALBHAI VITHALBHAI, Vyara, Tapti Railway.
TALLACKCHAND RAMCHAND, Vyara, Tapti Railway.

WADHWAN CITY—
RAJABALLI MIYABHAI.

WADHWAN JUNCTION—
AHMEDALLI JIWAJI.

WAGHORIA—
GORDHANDAS PURSHOTAM PANCHAL.

WANKANER—
TAJBHAI SULEMANJI.

YCULLA—
GULAMHUSEN ESUFALLY.
SAMSUDIN ABDOOLALLY.

Cement Stockists in C. P.

AKOLA—
ABDULALI BODALBHOY & SONS, Contractors.
ABDULALI MAMUJI, Merchant.
DAWOODBHAI KADERBHAI, Merchant.
JIWAJI ISMAILJI, Merchant.

AMRAOTI—
ABDULA AHMED, Merchant.
AKOLAWALA & BROS., T E., Contractors.
PEERMAHOMED NOORMAHOMED, Merchant.

ANJANGAON—
KAMRUDIN KADIBHOY & Co.

ARVI—
GULAMALI RASULJI, General Merchant.
THE HIND STORES

BERAR—
ABDULALI MAMUJI AKOLAWALA
GULABCHAND MANSURLAL & Co

BHANDARA—
ABHYANKAR, G V., General Merchant
TAYABALI KAMRUDDIN & SONS, General Merchants

BHOPAL—
NANAIALAL BINDRAVANDAS

BILASPUR—
EHSANHUSSAIN MULLA ABDULHUSSAIN, Sadar Bazar.
IBRAHIMJI MOOSAJI, Merchant.
MOHAMMADALI ADAMJI, Merchant, Sadar Bazar.

BURHANPUR—
GANPAT RAMJI TARE, Iron Merchant.

BURWAHA—
ESUFALLI GANIBHAI.

CHAMPA—
HAJI HAMADHUSSAIN KASAM, Merchant.

CHANDA—
ABDUL HUSAIN MULLA HASANALI, General Merchant.

DAMOH—
KAMRUDDIN ABDULRASOOL
MULLA MURAD ALI MULLA HASSANALI

DARWAHMOTIBAGH—
MAHOMEDALI MULLA ABDULHUSSAIN.

DHAMANGAON—
SALEBHOY ESOFALLY, Merchant.

DHAMTARI—
ISAACALI MULLA FAIZALI, Merchant.

GONDIA—

HINGANGHAT—
ALIBHAI HAKIMJI, Merchant.
EBRAHIMJI MULLA MOHOMEDALI, General Merchant & Supplier
HAJI REHMTOLA ALLANA & SONS, Merchants

INDORE—
DAYABHAI VASANJI.
MULCHAND JETHALAL DESAI, Sia Ganj.
THE INDIAN UNIVERSAL COMMERCIAL CO., Maharani Road, Siyaganj.

ITARSI—
RAISAHEB JUGALKISHORE & SONS.

JUBBULPORE—
RATTANCHAND KANCHEDILAL.
SULLEMANJI GANIBHAI, Kamima Gate.

KAMPTI—
GANESHRAM & Co., R., Contractors.
RAMDHAN PANNALAL, Merchant.

KATNI—
MULLA AHMEDALI & SONS, General Merchants

KATOL—
IMRANALI HASANALI, General Merchants.

KHAMGAON—
HASANALI JAFERJI, H. M., Merchant
HUSAINALI KIKABHOY, Merchant.
SHRINIVAS BALKISHANLAL, Merchant.

KHANDWA—
ABDUL HUSAIN JIWAJI, Merchant.
ABDULALI JIVAJI.
ESOOLALI GANIBHOY & SONS, Merchant.
JIVAJI AMIJI
FIDALI AKBARALI.

KHIRKIA—
NANDRAM JAVERCHAND.

MAIHAR—
THE STATE ENGINEER, Maihar State.

MALKAPUR—
KASAMALI MULA KAMRUDIN, Merchant.

MALWA—
MADAN MOHAN SETIAR & SONS.

MHOW—
FIDAHUSSAIN ALLIMOHMED.
MADANLAL SHIVABUX.

MURTIZAPUR—
KAMRUDIN KADIBHOY, Merchant.

NAGPUR—
AHSANHUSSAIN ABDULALI, Abidi Shop, General Merchant, Sitabaldi.
ALBUX, A., General Merchant, Itwaree.
HASOONJI & SONS, K. S. M., General Merchants, Itwaree.
MEHDI BAGH SHOP, General Merchants (Branches at Itwaree, Sitabaldi, & Sadar).
MOHOMEDBHOY ABDEALI, General Merchant, Itwaree.
MULLA FIDA ALI SULTAN ALI, Itwaree Bazar.
PATEL & Co., Hassanpuri Circle, No. 22.

PENDRA ROAD—
MOHAMMEDHUSSAIN GULAMALI.

PULGAON—
ASGAR ALI M. TAHERALI, General Merchants & Commission Agents.

RAIPUR—
ABDEALI ISMAILJI, Sadar Bazar.
AMIRALI MULLA MURADALI, Sadar Bazar.
GUPTA, S, Lime Merchant.
MULLA AHMEDJEEBHOY, General Merchant, Bansali Road.
SAFDARALI MULLA MURADALI, Sadar Bazar.
SHAMSUDDIN MULLA ZAKIUDDIN, Sadar Bazar

RAJNANDGAON—
HASANALI FAKHRUDDIN, Merchant

REWA—
MULLA ALIMOHAMMED RAJAB ALI.

SAONER—
BEJNATH SURJUPRASAD, B.O.C. Agent.

SAUGOR—
KURBANHOSAIN MULLA ABDULALI.
MULLA YOUSUFALI MULLA MOHAMMEDALI.

SHAADOL—
MULLA MOZAFFERHOSAIN.

SHEGAON—
SHRINIVAS BALKISHANLAL, Merchant.

SINDI—
ABDUL HUSAIN LUKMANJI, Merchant.

SINOR—
NAROTAM KUBERDAS.

TUMSAR—
GAYADIN BINDAPRASAD, Merchant.
RAMLAL RAMRATAN, Merchant

UMRER—
MAHADEO RAMCHAND, Merchant.
MEHDI BAGH SHOP, Merchant

VERORA—
ENAETALI VAHEDALI, Merchant.

WARDHA—
ALIBHOY ADAMJI, Merchant.
ALONI, R. N., Proprietor, The Saraswati Stores.
ESSAJI NATHOOBHAI, Merchant.
ISMAILJI ISAJI, General Merchant.
KADARBHOY RAJABALI, General Merchant.
MOHOMEDALI GULAMHUSAIN, M., General Merchant.

YEOTMAL—
DESHPANDE, V. T, Contractor.
SHRIKISHAN TORMAL, Contractor.

Cement Stockists in Hyderabad (Deccan).

HYDERABAD—
ABDUL SAMAD ABDUL MAJID, Afzul Ganj.
JALLAL MIYA, Afzul Ganj.
MOHOMED ABDUL LATIFF, Afzul Ganj.
PEERMAHOMED & Co.
SHAIKH ABDULLA SYED HUSSAIN, Afzul Ganj.
TEEKARAM AMAJI, D , Afzul Ganj.
VELLORE LINGAI & SONS, Afzul Ganj.
VELLORE VISHVANATHAM & Co., Afzul Ganj

SECUNDERABAD—
ALLADIN & SONS, Oxford Street.
BUSSA RANGAIAH, Mahakali Devi Road.
CHIDURA VASUDEV KANTAIA & Co , General Bazar.
GANJI VENKANNA & SON, General Bazar.
GARDA & Co., B. P., James Street.
KESHAVDASS JIVANDASS, Mahakali Devi Road.
PEERMAHOMED & Co., Oxford Street.
POGAKU SHANKRAIA NARAYANNA, General Bazar.
RAMANNA & SON, K. B., General Bazar.
RAMASWAMY & Co., A., General Bazar.
SECUNDERABAD COMMERCIAL & BANKING Co.
THE ENGINEERING STORES & MACHINERY AGENCY Co., LTD., James Street.
VEERANNA SIVAIAH, Y., Tobacco Bazar.

SHAHABAD (Deccan)—
SHAIK IMMAM.

Cement Stockists in Kashmir.

JAMMU—
NATHRADAS KABLIMAL, Iron Merchants.
PANNALAL NANAKCHAND JAINI, Iron Merchants.
THE SHALAMAR ENGINEERING WORKS.

Cement Stockists in Madras Presidency.

ANAKAPALLI—
BOGGARAPU SWAMY & SONS, Merchants.

BELLARY—
VATTAM GOPALAPPA & BROS.

BERHAMPORE—
RAMALINGAM, W V L N. Agent.

BEZWADA—
ALAPATI RAMAMURTY
CHITTURI PEDA PITCHIAH BROS.
GELLI KRISHNAMURTY.
GUNDIMEDA VENKATACHALAPATHY & BROS.
NANDIPATI JAGANNAYAKULU.
SASTRY, M V., Propnetor. Delta Trading Co.

CALICUT—
M COONMAHOMED & SONS
MADURA CO, LTD

COCANADA—
BEST & CO. LTD
MANDAVILLI RAMANNA
MANDAVILLI SATHILINGAM, Merchants
V S. NARAYAN, A P. RAJU & Co, General Merchants, Bridge Road.
PENUMOODI VENKATARATNAM BROS
VADAKATTU SURYAPRAKASAM, Merchants.

COCHIN—
AMRATLAL PREMJI
BEST & Co, LTD
GUNA SHENOY & BROS A.N.
HAJEE ABDUL KADER HAJEE JACOB
MADURA Co, LTD

COIMBATORE—
STANES & Co, LTD, T.
SIDDICK MEANJEE SAIT & SONS.

CUDDALORE—
PARRY & Co., LTD

ELLORE—
MANDALA SUBBARDA, Merchant.
MOTHAY KRISHNA RAO, Merchant.
VARADA RAMASWAMY, Merchant.

GUNTUR—
BATCHU SREERAMULU

MADRAS—
ABDOOL HOOSSAIN JEEVAJEE & Co., No. 9, Linga Chetty Street.
ABDUL SHUKOOR & BROS, No. 82, Sembudoss Street.
BADRUDDIN & Co, A.M., No 28, Linga Chetty Street.
BEST & Co., LTD.
GOOLAMALLY & Co., A.M., No. 20, Errablu Chetty Street.
HASSANALLY & Co, A.M., No. 34, Linga Chetty Street.
HUSSAIN & Co, M N, No. 90, Armenian Street.
KUPPUSWAMY NAICKER & SONS, No 144, Triplicane

MADRAS—
MAHOMED ISMAIL & Co
MAHOMED YUSUF, B.K, No 21, Errabalu Chetty Street
MAHOMED YUSUF, B K, No 30, Venkatachalla Mudali Street.
PARRY & Co., LTD , 1st Line Beach.
RAJU CHETTY, T S, 226, Rasappa Chetty Street
SAIFUDDIN & Co , M., Lunga Chetty Street.
SHAW WALLACE & Co., P.O. Box No. 14.

MADURA—
A & F HARVEY.
RAJAGOPALA IYER, O.K N.

MANGALORE—
KRISHNA NAYAK & SONS, M
MIRZAR ANNAPPA ANANTH PAI & SONS

MASULIPATAM—
ANNAM BRAHMANANDAM & CHITTURI MALLIKHARJANUDU.

RAJAMUNDRY—
BANDALA CHINA VEERASWAMY, Merchants
MIRIYALA VENKATARATNAM, Merchants
NAGAVARAPU BUTCHI ABBAYI, Merchants.
SINGAMSETTY PULLIAH & SONS, Merchants
THONTEPU SATYANARAYANA, Merchants.
T SATYANARAYANAMOORTY, Merchant
VETCHA SUBBA RAO, Merchants.
VUDDAGIRI SATYANARAYANA, Merchants

SAMALKOT—
MATTAPALLI RAJU SATTYAM, Merchants.

TENALI—
MALLESWARA STORES.
PENUGONDA NAGABHUSHANAM.

TRICHINOPOLY—
MEYYA ROWTHER.
THE CHIEF ENGINEER, S.I RLY. Co , LTD

TURNI—
BANDARU SATYANARAYANA, Merchant.

VIZAGAPATAM—
KOLLURU SESHAGIRI RAO.
SREERAMAMURTHY, G. K.
SRINIVASA RAO, K.

Cement Stockists in Mysore.

BANGALORE—
ABDUL HAKH, V.
CHANDAMEYAN SAHIB & SONS, Bangalore Cantt.
HAJEE ABDUL RAHIMAN SAHIB & SONS, Bangalore Cantt.
SIR HAJI ISMAIL SAIT, Bangalore.
NARAYANASWAMY & Co., B.V., Bangalore City.

MYSORE—
BHARAMIAH DHARANAPPA, G.K D.
SUNDRAM IYER, R.
SATHEPET—
B. BETTIAH, Fertiliser, Dealer & Commission Agent.

Cement Stockists in N. W. F. P.

ABBOTTABAD—
MANGAL SEN & SONS, Bankers.
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BIRD & Co, Chandni Chowk. (See page 133 & 134).
MAHABIR PERSHAD & SONS.

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BHAJAN MALL TOARA CHAND.

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PARAS RAM MEHAR CHAND

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ISMALJI & SONS
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DEVIDITTA MALL MUNSHI RAM
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MOHAR SINGH JIWAN SINGH, Cement Merchants

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RUTLAM—
HASANALLY NAZERALLY.
MOHMEDALLI TYEBALLI.
EBRAHIMJI LALABHAI.
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UJJAIN—
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BRITISH INDIAN IMPROVEMENT CORPORATION

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TEJPAL MANGAL SAIN.

ALLAHABAD—
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MAHADEO PRASAD BHAGWAN DASS, Johnstonganj.
NARAIN DASS HANS RAJ, Lukerganj.
NOORULLA GHAZANFARRULLA, Contractors, Nai Basti.
TEEKA RAM & SONS, Canning Road.

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BHARAT DAS SALIG RAM, Khattri Tola.
LACHMAN RAM TIRBENI PRASAD, Chowk.
RAM DAS SITA RAM, Matberganj.

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BANSIDHAR MATADIN, Steelganj.
BARATI MIYAN QADIR MIYAN, Chowk.
JAI DAYAL KASHMIRI LAL, Chauri Bazar.
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MULLICK & SONS, S C, Godhulia.
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BIRD & Co, P. O. Box No. 4. (See page 130 & 131).
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MATHULAL RAMNATH.
PUTTI LAL PRAG NARAIN, Nayi Sarak.
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BAIJ NATH RAM JIUT RAM.
NARAIN DAS GHANESHIAM DASS.

DERA-DUN—
KANSHI RAM PHOOL CHAND
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DIBAI—
RAGHUNATH DASS NATHI MALL.

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SUNDER LAL BABU RAM, Kirana Bazar

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BANWARI LAL LUXMI CHAND, Contractors.
RATEE RAM & SONS, Contractors.

FIROZABAD—
BHOLA NATHA & SONS.

FYZABAD—
GOBRI RAM TULSI RAM.
PACHKAURI KRISHNA TAMOLI & Co., Chowk.

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ONKAR LAL PREM SUKH, Near Rly. Station.
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SH. BARKATULLA SERAJUL HAQ, Sahebganj.
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KALOO RAM AMRITLAL.
SETH BAGAR MALL KANHIA LALL.

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ABBOTT BROTHERS, Contractors
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GYAN CHANDRA & Co , Latouche Road
MARTIN & Co., 1, Shahnajaf Road. (See page 152).
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SHADI RAM & SONS, Latouche Road.
SHRI RAM & Co , Latouche Road.
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PILIBHIT—
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VALLIJI MAHAMADALLI, Agra Road.

GODHRA—
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VORA ESUFALLY BADRUDIN & BROS

JALGAON—
FAJDEHUSAIN MOHAMEDALLY
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INAYAT HUSSAIN KAMRUDDIN.

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ABDULALI JIVAJI.
ESOOFALLY GANIBHOY.
JIVAJI AMIJI.

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HEATLY & GRESHAM, LIMITED, 6, Waterloo Street. (See page 141).
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(See page 148)
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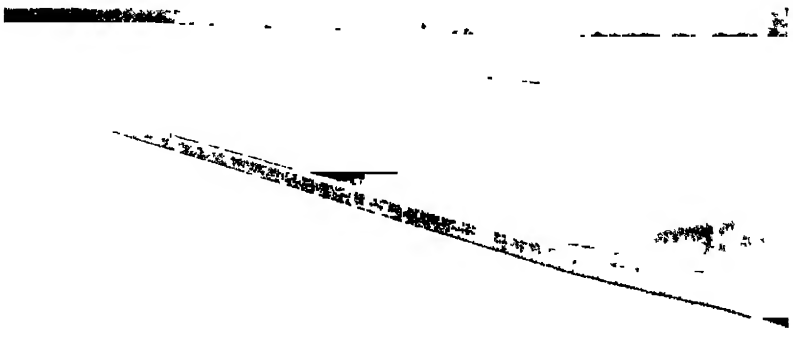

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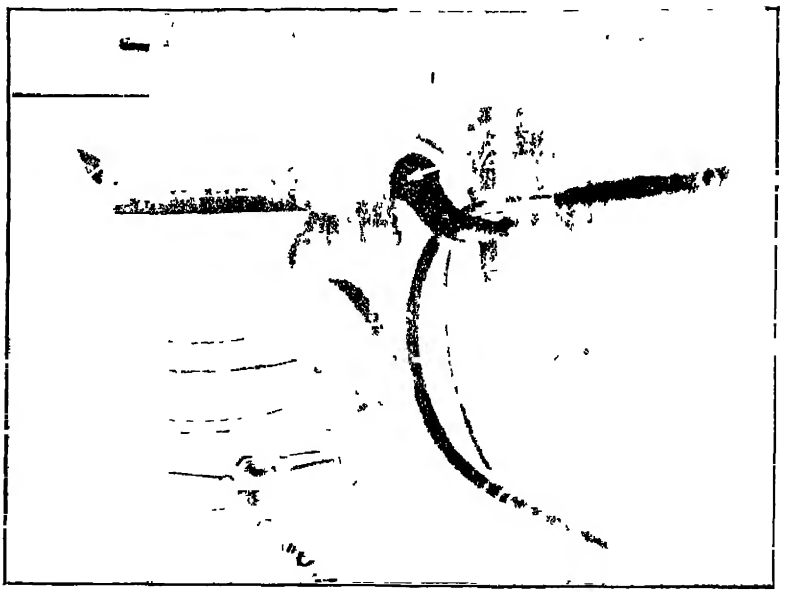

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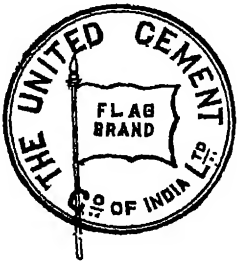

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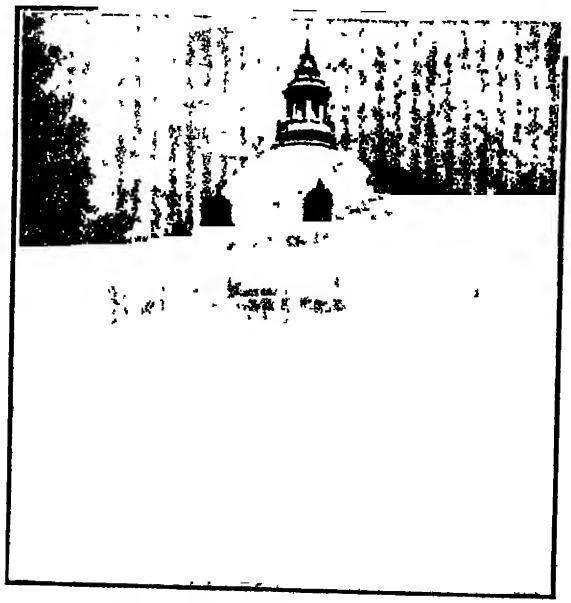

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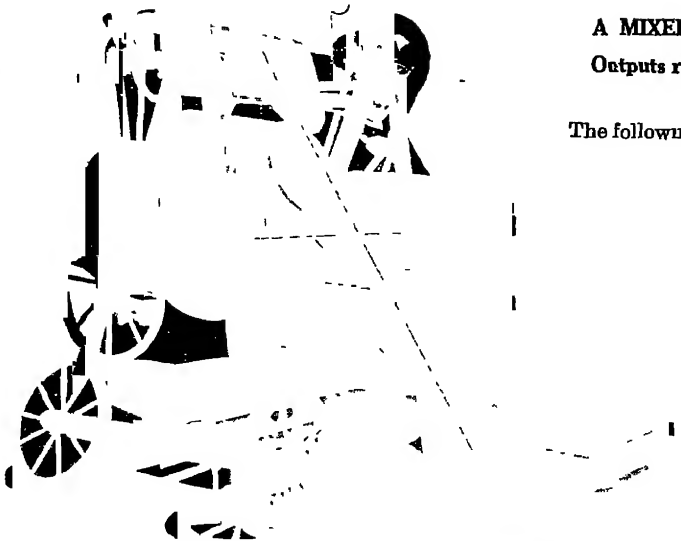

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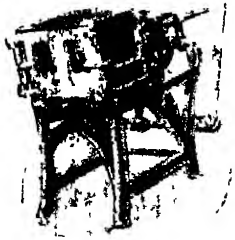

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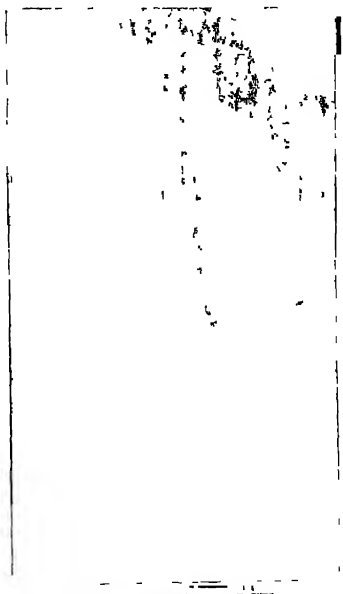

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